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COLLECTING SPHAERIID CLAMS

By H. B. Herrington*

Sphaeriid clams are small bivalve molluscs of the family Sphaeriidae. In temperate and subarctic North America the family is represented by the genera *Sphaerium* and *Pisidium* containing approximately twelve and twenty-two species respectively. An illustrated key to their identification has recently been published (Herrington, 1962).

Specimens of *Sphaerium* and *Pisidium* are common in many kinds of freshwater environments: lakes, ponds, swamps, rivers, small streams, canals, and drainage ditches. As such, they are an important food of many aquatic birds and bottom-feeding fish and are therefore of significance in productivity and wildlife management studies. They are also of some use as indicators of stream pollution (Ingram, *et al.*, 1953). In view of their importance, the following remarks are offered to assist limnologists, fisheries biologists, and shell collectors in the use of the special techniques necessary for successful qualitative collecting of these small molluscs.

There have been many articles in the past on how to collect various kinds of molluscs (cf., Am. Malacol. Union, 1955), and two papers by Sterki (1895, 1916) have dealt specifically with the collecting of sphaeriid clams. However, because detailed methods of securing the tiny molluscs are usually not covered in papers of a more general nature on collecting, and since Sterki's old articles are inaccessible to many collectors, it seems desirable at this time to present a brief discussion on collecting methods for sphaeriid clams.

In southern Ontario, sphaeriid clams are most abundant in the shallow water zone extending from shore to a water depth of approximately three feet. Most species are not restricted to such depths, however, but continue to occur sporadically down to a depth of twenty feet or more. Some species, such as *Pisidium conventus* Clessin and *P. idahoense* Roper, are only found in deeper water—fifteen feet or more. They occur in shallower water only in the far north or at considerable altitude. In large lakes most near-shore sphaeriids are found in sheltered bays, around islands, and in other places where the bottom is not significantly disturbed by wave action.

EQUIPMENT

The following basic equipment is recommended for collecting and sorting sphaeriid clams; rubber boots, shovel, dip-net, drag dredge, sieves, collecting cans and pails, drying and sorting trays, and tweezers. All, of course, are not always practical under all conditions.

Shovel. A round-pointed shovel with a long handle is recommended.

Dip-net. Suitable dip-nets may be purchased from biological supply houses or constructed by the collector. One such net which has proved most

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* Westbrook, Ont.

PLATE I

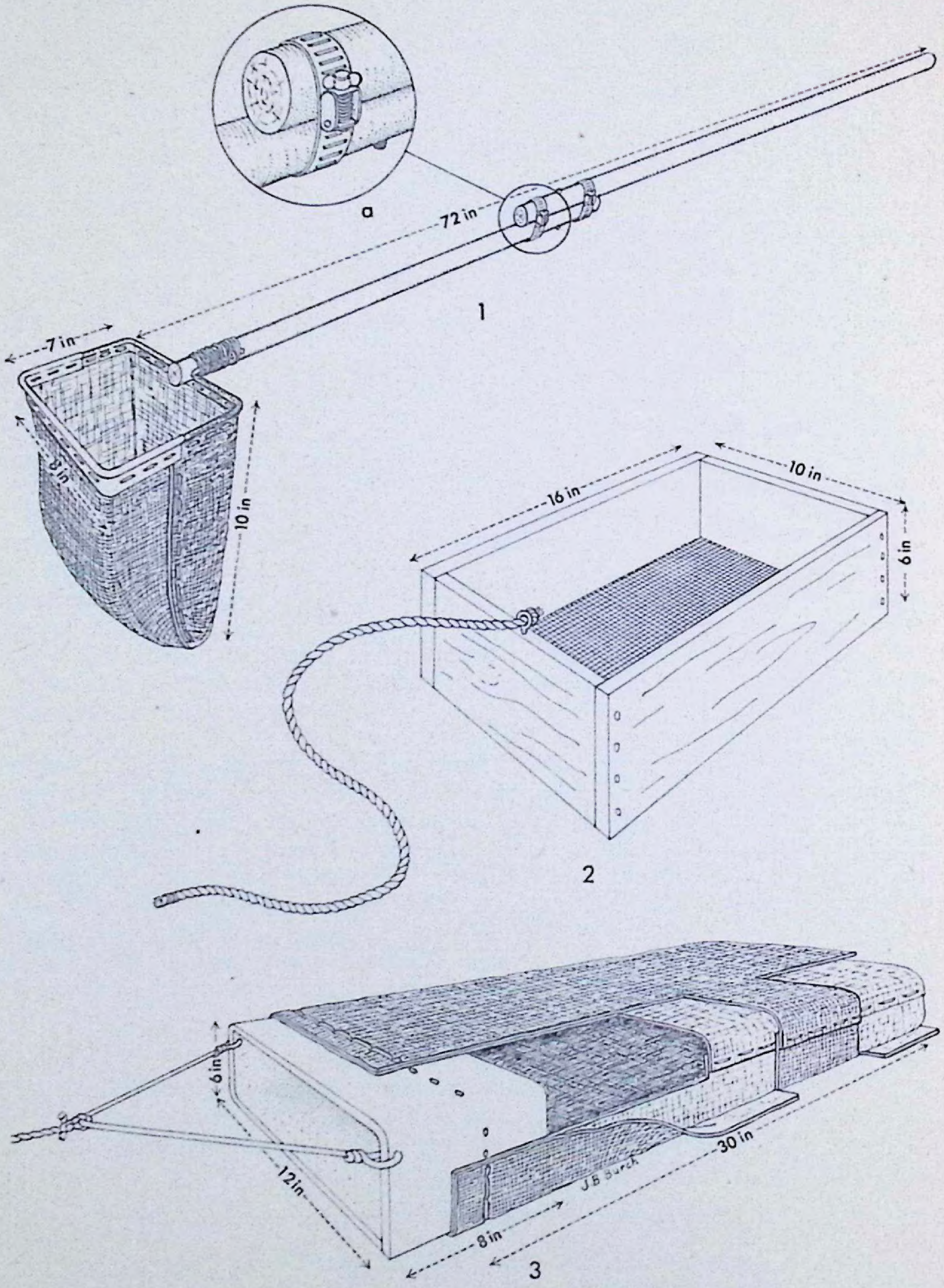

FIG. 1. Dip-net, made from round iron, a broom handle, and a piece of burlap; FIG. 2. Sieve, made from a wooden box, brass wire screening, and cord and screweye; FIG. 3. Drag dredge made from galvanized iron, two burlap potato sacks, a piece of wire, and some sash cord.

successful is illustrated in Plate I, fig. 1. This dip-net is constructed from ¼-inch round iron, a broom handle, and a piece of burlap. To extend its length, a second handle may be clamped to the first. This extension can be removed for more convenient transportation.

Drag dredge. The dredge shown in Plate I, fig. 3, was made from ⅛-inch galvanized iron 8 by 36 inches, two burlap 75-pound potato sacks, a piece of wire, and 200 feet of sash cord. For readily determining the depth of the water, this cord should be marked with paint or string at regular intervals. The outer sack is open at the top and bottom and serves to protect the inner one from wear and tear.

Sieve. The sieve (Plate I, fig. 2) is constructed of a wooden box, a 16- to 17-mesh brass wire screening, and a cord and screweye. In use, this cord is either attached to one of the collector's rubber boots or to the boat.

Two other sieves, of ¼-inch and ⅛-inch mesh respectively, should be prepared for screening dry debris (*see* below). If the sieves are so constructed as to fit one inside the other, they will take up less space for storage and transportation.

Collecting pail. An ordinary 10- to 12-quart pail is most suitable. By means of a wooden framework of 1- by 1½-inch material made to fit the pail about half-way up, and having a screweye, a piece of rope, and a small anchor, the pail when partly full of water can be kept sitting upright near the collector.

Specimens for anatomical study. If any specimens are to be taken for anatomical purposes, I find it best to pick them directly from the sieve before its contents are emptied into the pail and put them into a small jar of water. These specimens can later be relaxed (*see* van de Schalie, 1953), fixed, and preserved. Formalin should never be used as a preservative for sphaeriids because the shell dissolves when left in such a solution for an extended period of time. I find 70 per cent ethyl alcohol most suitable.

Collecting cans or containers. These are used to hold the contents from the collecting pail, which should be transferred to one of these containers before proceeding to another collecting station. A label giving the station number, location, date, and so forth, should be placed inside each container.

Drying trays. If the specimen has been completely dried, it can be picked out of the debris more readily. For this purpose the contents of each can are spread on a sheet of galvanized iron about 30 inches square. If the debris is stirred from time to time, drying is hastened. When the debris has dried, sorting may be facilitated by screening the material through the coarse (¼-inch) and fine (⅛-inch) mesh sieves.

Sorting tray. This can be any convenient flat surface, preferably portable. A small sheet of galvanized iron about 15 inches square, one surface of which has been marked off by paint into twelve equal areas (one horizontal and five upright bars), has been found satisfactory for sorting.

Tweezers. Because of the fragility of many sphaeriid clams, ordinary metal tweezers (or forceps) are unsatisfactory. The pressure required to bring the opposing points together is difficult to control and often crushes the shells. Home-made tweezers from a ¾- by 6-inch celluloid strip bent around a small piece of wood (¾ inch long) are most satisfactory. The celluloid is pointed at each end (opposing ends) and attached to the wood with two tacks.

USE OF EQUIPMENT

When collecting in two feet of water or less, if the bottom is moderately soft, good use can be made of the round-pointed shovel. This is used to skim the surface of the bottom, and the material obtained is then washed in the sieve. All the mud and fine sand will pass through. The coarser material—debris, plants, large pebbles, and so forth—is discarded. By tipping the sieve and moving it slowly, nearly submerged in the water, a large part of the fine debris that is lighter than the specimens can be removed. The remaining finer material is then put into the collecting pail and later into the cans.

If the bottom is very soft, or if the depth exceeds two feet, the dip-net is used instead of the shovel. By clamping the second broom handle to the first, it can be used from a boat to a depth of five feet or so. For collecting at depths greater than this, the dredge is used. This is dragged behind a rowboat, and the contents are emptied into a tub in the boat. From this the debris can be readily dipped into a sieve which rides in the water by the side of the boat.

The debris is dried on tins and sifted, and the specimens are picked out with tweezers. The specimens are then cured in alcohol (*see* below) and again dried and stored in this dry state with a label that has an ample amount of data.

Preparing specimens for storage. My method is to put the specimens in 70 per cent alcohol for from one to three or more days, depending on the size of the specimens. They are then dried and stored. The alcohol treatment prevents decay of the soft parts which will dry and remain free from odour. In this way they will keep for centuries.

Specimens are of value to museums only if they are accompanied by a label bearing adequate data. Ideally, labels should be of high rag content paper, and data should be entered in india ink. An example of adequate data is as follows: Moira River, at Mink's Bridge between Strathcona and Napanee, Hungerford Twp., Lennox and Addington Co., Ontario, John Smith Coll'r. (not just coll., for coll. may stand for collector or collection), July 1, 1957. If the depth of the water, kind of bottom, abundance and kind of vegetation, and other ecological information are also included, the value of the specimens will be greatly enhanced.

ACKNOWLEDGMENTS

The writer wishes gratefully to acknowledge the assistance received in preparing this paper from John B. Burch and William H. Heard, University of Michigan, and Arthur H. Clarke, Jr., National Museum of Canada.

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SUBLITTORAL MOLLUSCS AND BRACHIOPODS FROM THE GULF OF ST. LAWRENCE

By Arthur H. Clarke, Jr.

INTRODUCTION

Between October 5 and 13, 1960, the Research Vessel *A. T. Cameron,* operated by the Fisheries Research Board of Canada, conducted investigations off the Gaspé Peninsula and in the western Gulf of St. Lawrence. During the course of the work, which involved frequent use of an otter trawl in depths of 30 to 202 fathoms, numerous molluscs and other invertebrates were brought up. These were gathered and shipped to the National Museum of Canada. This report will deal with the molluscs and brachiopods which were collected.

Only the larger species were retained by the one-inch mesh which lined the cod end of the net. Nevertheless, the collections are significant because they provide information on the relative abundance and the bathymetric range of some of the species in this bio-geographic border area. The large number of specimens collected also helps to make possible an objective evaluation of the status of some of the species and subspecies of the region. Such an assessment of *Aporrhais occidentalis mainensis* Johnson will be attempted here. Other taxa will be similarly considered when adequate samples from other regions become available.

Stations Visited and Molluscs Collected

Table 1. *A. T. Cameron trawling stations, October 1960*

Sta. No.	Date	N. Lat.	W. Long.	Depth (fm)	Molluscs and brachiopods	
					No. alive	No. dead
1...........	Oct. 4	48° 26′	63° 47′	67–69	105	22
2...........	Oct. 5	48° 10′	63° 52′	43–45	160	52
3...........	Oct. 5	48° 00′	64° 26′	50–60	112	124
4...........	Oct. 7	48° 18′	64° 38′	30–50	159	96
5...........	Oct. 7	48° 18′	64° 38′	30–50	353	354
6...........	Oct. 7	47° 45′	64° 11′	30	135	29
17...........	Oct. 11	48° 27′	62° 06′	202	51	46
18...........	Oct. 11	48° 20′	62° 02′	150–155	1	0
19...........	Oct. 11	48° 19′	62° 03′	123–126	0	0
20...........	Oct. 11	48° 20′	62° 08′	98–102	1	0
21...........	Oct. 11	48° 16′	62° 03′	74–76	0	2
22...........	Oct. 11	48° 11′	62° 07′	50–51	16	11
23...........	Oct. 11	48° 11′	62° 10′	50	19	1
24...........	Oct. 11	48° 18′	62° 06′	100	0	0
25...........	Oct. 11	48° 20′	62° 04′	115–125	0	0
26...........	Oct. 11	48° 20′	62° 00′	150	11	0
27...........	Oct. 11	48° 27′	62° 06′	200	0	0
28...........	Oct. 12	48° 19′	62° 06′	110–112	2	0
31...........	Oct. 12	48° 19′	62° 06′	110–112	8	11

ACKNOWLEDGMENTS

Dr. W. R. Martin, scientist in charge of the cruise of the *A. T. Cameron*, generously provided the facilities which enabled the National Museum to participate in this investigation. Other assistance was given by members of the Museum staff: Mr. Stanley W. Gorham collected and preserved the specimens on board ship, and Elizabeth Macpherson did much of the preliminary sorting and assisted in other aspects of the study. Prof. Gilbert L. Voss, University of Miami, kindly examined the Cephalopoda and slightly altered one of the author's identifications. All this aid is sincerely appreciated.

Table 2 lists the species of molluscs and brachiopods which were

TABLE 2. *Relative abundance of living molluscs collected*

Species	Depth (fm)													
	30	30–50	30–50	43–45	50	50–51	50–60	67–69	98–102	110–112	110–112	150	150–155	292
	Station No.													
	6	4	5	2	23	22	3	1	20	28	31	26	18	17
Lepeta caeca Müller	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Margarites costalis Gould	0	1	4	2	0	0	1	0	0	0	0	0	0	0
Natica clausa Brod. & Sby	2	2	2	2	0	0	2	1	0	0	0	0	0	0
Lunatia pallida Brod. & Sby	1	2	2	2	1	1	3	1	0	0	0	0	0	0
Aporrhais occidentalis occidentalis Beck	1	1	4	1	0	0	2	0	0	0	0	0	0	0
Boreotrophon clathratus Linn	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Buccinum plectrum Stimpson	0	0	0	0	1	0	0	0	0	0	0	0	0	0
Buccinum tenue Gray	5	5	5	5	3	5	4	4	0	0	0	0	0	0
Buccinum undatum Linn	3	4	4	4	0	4	5	3	0	1	0	0	0	1
Buccinum glaciale Linn	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Plicifusus kroyeri Möller	0	1	1	0	0	0	2	0	0	0	0	0	0	0
Neptunea despecta tornata Gould	2	1	3	2	0	0	1	1	0	0	0	1	1	0
Volutopsius largillierti Petit	0	1	0	1	0	0	1	2	0	0	0	0	0	0
Jumala ossiani Friele	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Colus islandicus Gmelin	0	0	0	0	0	2	0	2	0	1	1	0	0	0
Colus pubescens Verrill	0	0	0	0	1	0	0	5	0	0	0	0	0	0
Colus spitzbergensis Reeve	1	1	3	2	0	0	1	0	0	0	0	0	0	0
Yoldia limatula Say	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Chlamys islandicus Müller	0	4	4	2	5	0	4	2	0	0	1	0	0	5
Placopecten magellanicus Gmelin	0	0	0	0	0	0	2	0	0	0	0	0	0	0
Musculus laevigatus Gray	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Musculus niger Gray	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Anomia aculeata Müller	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Astarte borealis Schumacher	0	0	0	1	1	0	0	1	0	0	0	0	0	0
Astarte undata Brown	0	0	0	1	0	0	3	1	0	0	0	0	0	0
Astarte subaequilatera Sby	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Venericardia borealis Conrad	0	0	1	0	0	0	2	1	0	0	0	0	0	0
Clinocardium ciliatum Fabricius	3	1	3	1	0	0	4	1	0	0	0	0	0	0
Serripes groenlandica Gmelin	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Hiatella arctica Linn	0	1	1	0	0	0	1	1	0	0	0	0	0	0
Illex illecebrosus Lesueur	0	0	1	0	0	0	1	1	0	0	0	0	0	0
Rossia megaptera Verrill	0	0	0	0	0	0	0	0	1	0	0	2	0	1
Bathypolypus arcticus Prosch	0	0	0	0	0	0	0	2	0	0	0	3	0	2
Rhynchonella psittacea Müller	0	0	2	0	1	0	0	0	0	0	0	0	0	0

collected alive at the various stations. The stations are arranged in order of increasing depth. The species are recorded on an arbitrary scale of 0 to 5 as follows: 5, abundant and dominant; 4, abundant but not dominant; 3, common; 2, uncommon; 1, rare; and 0, absent.

Conclusions regarding the changes in relative abundance of the species with increasing depth are largely self-evident from the table. However, it is interesting to note that *Buccinum tenue* is the most abundant gastropod in all six of the stations with depths of 30 to 51 fathoms. As depth increases, *B. tenue* is displaced first by *B. undatum* and *Colus pubescens* and then by several other whelks, none of which appear to be dominant. Several species appear to be very erratic in their distribution, eleven of them occurring at only a single station. The small size of most of the collections from depths of 98 to 155 fathoms obscures species relationships in this zone, however.

Of the 34 species of molluscs and brachiopods found alive, only three represent extensions in known bathymetric ranges. These are, *Volutopsius largillierti* (50–67 fm, this survey; 50 fm, La Rocque, 1953). *Chlamys islandicus* (45–202 fm, this survey; [0]–195 fm, Ocklemann, 1958), and *Rossia megaptera* (102–150 fm, this survey; 150–640 fm, LaRocque, 1953). In addition, a single specimen of *Buccinum glaciale,* a species for which no bathymetric data could be found, occurred at station 4 (30–50 fm). All 34 species have been recorded from the Gulf of St. Lawrence by Whiteaves (1901) or LaRocque (1953) except for *Jumala ossiani* which is recorded in Canada only from the Grand Banks in 180 fathoms and from Murray Bay, St. Lawrence River, Quebec. The latter record is questioned by LaRocque as probably representing a Pleistocene fossil.

In addition to living specimens, dead shells of most of the species occurred at many stations. Numerous single valves of *Serripes groenlandica* were found at stations 2, 3, 4, 5, 6, and 17. Valves of *Clinocardium ciliatum* were abundant at stations 1, 2, 3, 4, 5, and 17. Some infaunal species occurred in the trawl only as dead shells, viz., *Mytilus edulis* Linn. (sta. 5), *Arctica islandica* Linn. (sta. 3), *Macoma calcarea* Gmelin (sta. 4, 5, 17, and 22), *Spisula polynyma* Stimpson (sta. 3, 4, and 6), *Mesodesma arctata* Conrad (sta. 5), *Mya arenaria* Linn. (sta. 4 and 5), *Mya truncata* Linn. (sta. 4), *Panomya arctica* Lamarck (sta. 5 and 17), and *Cyrtodaria siliqua* Spengler (sta. 1, 2, 3, 4, 6, 21, and 31).

REMARKS ON THE STATUS OF APORRHAIS OCCIDENTALIS MAINENSIS JOHNSON

In 1926, Johnson described (p. 133) *Aporrhais occidentalis mainensis* from specimens collected in the Gulf of Maine and the Bay of Fundy. Four years later he figured *mainensis* (1930, Plate 1, figs. 4–6) and restricted the type locality to Gillpatrick Ledge off Northeast Harbor, [Mount Desert Island,] Maine, in 5 to 6 fathoms. No general acceptance of the name has occurred, however.

A large series of *A. occidentalis* Beck[1] was collected during the present survey at station 5 (off Chaleur Bay, Gulf of St. Lawrence, 30–50 fm). The specimens agree with Beck's description and figure, as given by

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[1] *Rostellaria occidentalis* Beck, Guerin's Mag. de Zool., 1836, vol. 6, classe 5 (text), plate 72. This publication was unavailable to the writer.

Johnson (1930: 1–2), and since they are from the type area ("Gulf of St. Lawrence"), they may be regarded as *A. occidentalis* s.str.

Another large series of *Aporrhais* collected by Frits Johansen in 1917 is available for comparison. These were trawled in 52 fathoms between Campobello Island and The Wolves Islands near the mouth of the Bay of Fundy. They agree closely with the description and figures of *mainensis* by Johnson (1930) and are here referred to that subspecies.

A number of differences are clearly visible between the two lots. The specimens of *mainensis* are smaller and thinner-shelled than those of *occidentalis,* the distal portion of the lip is less thickened, the ribs are coarser and fewer in number, and the brown periostracum is more apparent. All the adult specimens in each lot were measured for length and maximum lip thickness, and the number of ribs on the penultimate whorl of each shell was counted. The results are tabulated in Table 3.

TABLE 3. *A comparison of A. occidentalis* s. str. *and A. occidentalis mainensis*

—	*A. occidentalis* s. str.		
	Length (mm)	Lip thickness (mm)	Ribs on penultimate whorl
N	48	47	164
maximum	60	8.0	22
minimum	45	4.0	14
mean	53.2	5.9	17.8
standard deviation	3.58	1.02	1.89
	A. o. mainensis		
N	133	114	133
maximum	52	6.0	18
minimum	40	1.0	12
mean	45.4	2.7	14.7
standard deviation	2.82	1.08	1.11

Application of the 75-percent-rule gives the following values for coefficient of difference (C.D.) and percentage non-overlap (N.O.) of the two samples—length: C.D. 1.22, N.O. 89 per cent; lip thickness: C.D. 1.54, N.O. 94 per cent; rib number: C.D. 1.01, N.O. 84 per cent. The conventional level of subspecific difference is 90 per cent N.O. for a single character

In the present case the non-overlap value for lip thickness is above the 90 per cent level, the value for length is virtually at that level, and the value for rib number is below 90 per cent, although it is still rather high. Since the two forms are allopatric (Johnson, 1930, and personal observation by this writer) and show significant differences, it seems that *mainensis* should indeed be regarded as a valid subspecies of *occidentalis* s.str.

The proper systematic status of *A. o. labradorensis* Johnson (1930: 3, Plate 1, figs. 2, 3) still remains to be verified. In addition, specimens of *occidentalis* from off Cape Ann, Massachusetts, are unusually short and exhibit a very large and heavily-thickened lip. Only additional collections of large series will make objective decisions possible, but at the present time it appears not unlikely that several strongly differentiated subspecies, or even separate species, may exist within the range of this polymorphic group.

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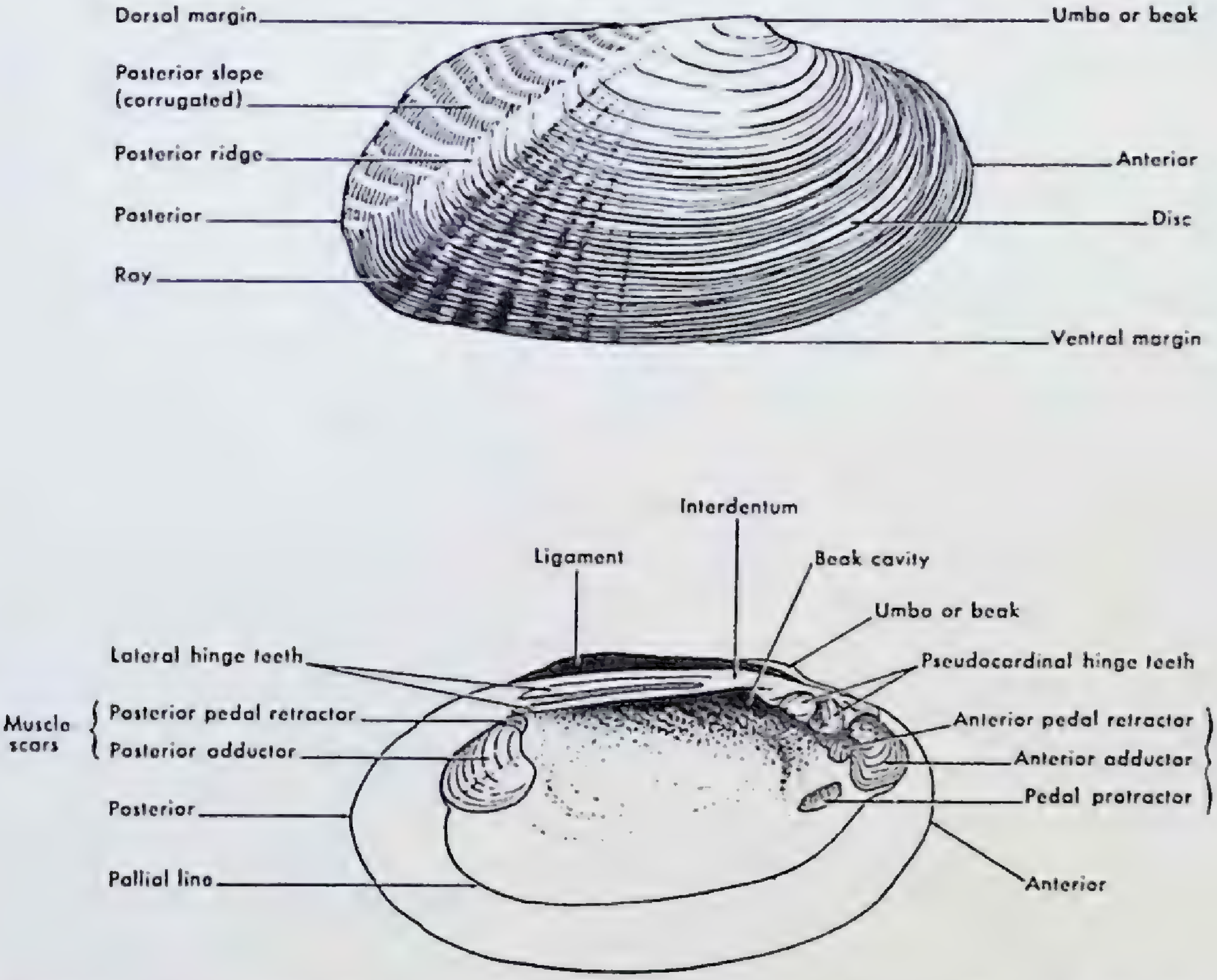
THE FRESHWATER MUSSELS OF NOVA SCOTIA

By H. D. Athearn[1] and A. H. Clarke, Jr.[2]

INTRODUCTION

The material for this study was collected by one of us (Athearn) during seven trips to Nova Scotia between 1946 and 1954 and by the other (Clarke) during a single expedition in the summer of 1960. Specimens were found at seventy-one localities, and although the region near Halifax was most thoroughly covered, collections were made in nearly all the counties within the province. Additional records were obtained from the collections in the National Museum of Canada and the Museum of Comparative Zoology. It is felt that the coverage is now sufficiently complete to allow some general conclusions to be made with respect to the zoogeography of the Unionacea in Nova Scotia and its significance.



Text fig. 1. External and internal morphology of typical unionid shells. Upper figure, *Lasmigona costata* (Say) (schematic). Lower figure, *Lampsilis radiata radiata* (Gmelin). From Clarke and Berg, 1959.

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[2] National Museum of Canada, Ottawa.

As far as we now know, Nova Scotia contains nine clearly defined species of freshwater mussels and a tenth form whose status will be discussed. Although the narrow and marshy Isthmus of Chignecto provides the only land connection between Nova Scotia and the mainland, the total number of unionid species present is not significantly less than what might be expected if a much wider and more suitable land bridge existed. The only apparently missing species is *Alasmidonta heterodon* (Lea). That species has been found in the Petitcodiac River of New Brunswick (Athearn, 1953) and not in Nova Scotia. Its distribution is erratic and discontinuous even on the mainland, however (Clarke and Berg, 1959).

Before proceeding to discuss the ecology and systematics of the species and the details of their distribution, it is appropriate to consider briefly the work which has already been done on the unionid fauna of Nova Scotia.

PREVIOUS WORK

Only two reports dealing exclusively and comprehensively with the molluscs of Nova Scotia have been issued. The first was by Willis (1857) who, in a privately published and remarkably complete catalogue, cited 193 species of marine, land, and freshwater molluscs and even included locality data, all on a single page. Of the eight unionids included, the only ones that can be positively identified are *Unio complanatus* Lea (=*Elliptio complanatus* (Solander)), *Unio radiata* Lam. (=*Lampsilis radiata radiata* (Gmelin)), *Anodonta implicata* (=*Anodonta implicata* Say), and *Alasmidonta margaritifera* (=*Margaritifera margaritifera margaritifera* (Linn.)). The other species can be identified only tentatively and in part, viz., *Unio* . . . (?) "Dartmouth Lakes" (possibly *Alasmidonta undulata* (Say)), *Anodonta ferussaciana* "Dartmouth Lakes, common" (probably *Anodonta cataracta* Say), and *Anodonta* . . . (?), "two varieties . . . St. Mary's river, Truro" (unidentifiable).

The second report was by Jones (1877) who included four unionids among the 189 species of marine, land, and freshwater molluscs listed from the province. All are readily identifiable. They are *Unio complanatus* Lea (=*Elliptio complanatus* (Solander)), *U. radiatus* Barnes (=*Lampsilis radiata radiata* (Gmelin)), *Margaritana arcuata* St. (=*Margaritifera margaritifera margaritifera* (Linn.)), and *Anodon implicata* Gould (=*Anodonta implicata* Say).

Additional studies that give information on the freshwater mussels of Nova Scotia are by Simpson (1914), Ortmann (1919), Brooks (1936), Smith (1938), Brooks and Brooks (1940), Johnson (1946, 1947), Athearn (1953, 1961), La Rocque (1953, 1961a, 1961b), and Clarke and Berg (1959). Smith lists *Anodonta marginata* Say as occurring in Lake Jesse, Yarmouth County, but, as pointed out elsewhere (e.g., Clarke and Berg, l.c.) the status of that species is in doubt. None of the other workers cited give additional species specifically from Nova Scotia. Simpson and several subsequent authors, however, list *Anodonta cataracta* Say, *Alasmidonta undulata* (Say), *Lampsilis cariosa* (Say), *Ligumia nasuta* (Say), and *Strophitus undulatus* (Say) (often as *S. rugosus* Swain.) as occurring in the Atlantic drainage from the St. Lawrence system south, thereby implying that they may be expected to occur in Nova Scotia.

PRELIMINARY CONCLUSIONS

The present authors have collected the following species of unionids in Nova Scotia:

Margaritifera margaritifera margaritifera (Linn.)
Elliptio complanatus (Solander)
Alasmidonta undulata (Say)
Alasmidonta varicosa (Say)
Strophitus undulatus (Say)
Anodonta implicata Say
Anodonta cataracta cataracta Say
Anodonta cataracta brooksiana van der Schalie
Lampsilis ochracea (Say)
Lampsilis radiata radiata (Gmelin)

The distribution of freshwater mussels in Nova Scotia is by no means random or uniform. *S. undulatus* and *L. ochracea* are each known from only a single locality close to the Isthmus of Chignecto. *A. undulatus, A. varicosa,* and *L. radiata* are more generally distributed but have not reached either the northern or southern extremities of the province. *M. margaritifera, E. complanatus, A. implicata, A. c. cataracta,* and *A. c. brooksiana* have migrated farther and appear to occur all over Nova Scotia (*see* Maps I to VI). Clearly, postglacial repopulation of the province has not yet reached completion but is still going on.

It is of interest to note that the distribution of freshwater mussels corresponds roughly to the pattern observed by Livingstone (1951) for the freshwater fishes, i.e., an irregular but progressive decrease in the number of species present with increased distance from the Isthmus of Chignecto. Of course, mussel glochidia in general are obligate parasites of certain species of fish, and such a correlation in distribution patterns is probably not coincidental. More information is necessary on what species of fish are parasitized by the mussels in question before a more detailed examination of this correlation can be made.

Since neither *Ligumia nasuta* nor *Lampsilis cariosa* has been collected northeast of Maine, their apparent absence from Nova Scotia is not surprising. Both of these species, and *Alasmidonta heterodon*, may eventually be found to occur in that province, however; and for that reason all three have been included in the key.

Key to the Freshwater Mussels of Nova Scotia*

1. Articulating hinge teeth absent or vestigial 2
Articulating hinge teeth present 5

2. Vestigial pseudocardinal teeth indicated by a depression and thickening just anterior to beak. Beak sculpture coarse and without a central sinuation. Shell not noticeably thickened anterior-ventrally. Length not exceeding 100 mm. Rare in Nova Scotia.............................. Strophitus undulatus (Say), pl. 3, figs. 7 and 8.
Shell not as above 3

3. Nacre salmon or copper coloured. Shell prominently thickened anterior-ventrally. Length of adult specimens exceeding 100 mm. Common. .... *Anodonta implicata* Say, pl. 2, figs. 1 and 2.
Shell not thickened anterior-ventrally 4

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*Adapted from Clarke and Berg, 1959. All species found in the Maritime Provinces of Canada and the Atlantic Drainage of the United States south to and including the Delaware River system are treated in the key.

4. Umbones close to the anterior end and not prominent. Beak sculpture mainly concentric, with many ridges (often 10 to 12) and extending rather far out on the shell. Common. ....*Anodonta cataracta brooksiana* van de Schalie, pl. 2, figs. 3 and 4.

Umbones not so close to the anterior and more prominent. Beak sculpture sinuous or concentric, with fewer ridges (often 5 to 7) and not extending far out on the shell. Common. ....*Anodonta cataracta cataracta* Say, pl. 2, figs. 5 and 6.

5. Shell sculptured on posterior slope by ridges crossing lines of growth. Posterior ridge inflated and rounded. Periostracum extensively rayed. Length not exceeding 80 mm. Found only in streams. Uncommon. ....*Alasmidonta varicosa* Say, pl. 3, figs. 5 and 6.

Shell not sculptured on posterior slope and otherwise not as above 6

6. Articulating lateral teeth short, poorly developed, or absent 7

Articulating lateral teeth elongate and well developed 8

7. Adult length exceeding 90 mm. Height/length usually less than .50. Valves often arcuate. Periostracum dark and rayless. Found only in streams. Common. ....*Margaritifera margaritifera margaritifera* (Linn.), pl. 1, figs. 1 to 4.

Adult length less than 90 mm. Height/length more than .50. Valves not arcuate. Periostracum dark or lighter and with rays. Found in streams and lakes. Moderately common........*Alasmidonta undulata* (Say) pl. 3, figs. 3 and 4.

8. Adults small, not exceeding 50 mm in length. Lateral teeth double in the right valve and single in the left. Not recorded from Nova Scotia. ....*Alasmidonta heterodon* (Lea), pl. 3, figs. 1 and 2.

Adults exceeding 50 mm in length. Lateral teeth single in the right valve and double in the left 9

9. Shell elongate (height/length less than .48) or subcylindrical (width/height more than .60) or both. Periostracum brownish black or black and not extensively rayed. Posterior end extended and bluntly pointed centrally. Nacre purple or white. Not recorded from Nova Scotia. ....*Ligumia nasuta* (Say), pl. 1, figs. 7 and 8.

Shell not as above 10

10. Shell variable, usually subrhomboid, rather compressed, and obliquely subtruncate. Posterior ridge present. Periostracum usually dark and rayless. Nacre usually purple. Height/length usually less than .60. Common in lakes and streams.. ....*Elliptio complanatus* (Solander), pl. 1, figs. 5 and 6; pl. 4, figs. 7 and 8.

Shell subelliptical or subovate and often more or less rayed. Posterior ridge nearly absent. Nacre not purple. Height/length more than .60 11

11. Shell medium or small (length less than 80 mm) and relatively thin. Pseudocardinal teeth and interdentum thin and compressed. Sexual dimorphism well marked. Rare. ....*Lampsilis orchracea* (Say), pl. 4, figs. 3 and 4.

Shell larger (length more than 80 mm) and of medium thickness. Pseudocardinal teeth well developed and not compressed 12

12. Shell without rays or rays on posterior slope only. Periostracum yellowish and shiny. Sexual dimorphism well marked. Not recorded from Nova Scotia. ....*Lampsilis cariosa* (Say), pl. 4, figs. 1 and 2.

Shell with rays generally distributed over the whole shell. Periostracum yellowish or brownish and not shiny. Sexual dimorphism obscure. Relatively common. ....*Lampsilis radiata radiata* (Gmelin), pl. 4, figs. 5 and 6.

In the following table abbreviations are used to express the relative abundance of species. These are—'A' for abundant (specimens found at the rate of 30 or more per half-hour of collecting), 'C' for common (10 to 29 per half-hour), 'O' for occasional (3 to 9 per half-hour), and 'R' for rare (1 to 2 per half-hour).

TABLE I. *Locality, habitat, and abundance data for stations cited*

Sta. No.	Locality	Habitat	*M. m. margaritifera*	*E. complanatus*	*A. undulata*	*A. varicosa*	*A. implicata*	*A. c. cataracta*	*A. c. brooksiana*	*S. undulatus*	*L. ochracea*	*L. r. radiata*
	CUMBERLAND COUNTY:											
1	Halfway River West Lake, 1 mi. S. of Newville	Small lake. Bottom muddy, vegetated.		A	R				A			R
2	River Hebert, Newville	Just below lake outlet. Current moderate. Bottom, sand.		A	R				O		R	C
3	Maccan River, Southampton	Stream rapid and cold. Bottom rocky. Total hardness 24 p.p.m.	C									
4	Tidnish River, 10 mi. ENE. of Amherst	Stream narrow and rather rapid. Bottom, sand and rock.	O	C					O	C		
5	River Philip, 1 mi. S. of town of River Philip	River medium sized, rather rapid and shallow. Bottom, gravel and rocks.	C									
6	River Philip, 3½ mi. N. of Collingwood	River medium sized. Current moderate. Bottom, sand, gravel, and rocks.	O									
7	Wallace River, 9 mi. S. of Pugwash	River wide, shallow. Current moderate. Bottom, rocks and gravel.	A			O						
	ANTIGONISH COUNTY:											
8	West River Antigonish, 2 mi. S. of Antigonish	River wide, shallow. Current rather swift. Bottom, gravel.	A									
9	South River Antigonish, 2 mi. S. of South River	River medium sized, shallow. Current moderate. Bottom gravel.	A									
	INVERNESS COUNTY:											
10	McIntyre Lake, 8 mi. ENE. of Port Hawkesbury	Small pond. Bottom sand and gravel.		A	R		R		C			

Sta No.	Locality	Habitat	*M. m. margaritifera*	*E. complanatus*	*A. undulata*	*A. varicosa*	*A. implicata*	*A. c. cataracta*	*A. c. brooksiana*	*S. undulatus*	*L. ochracea*	*L. r. radiata*
	INVERNESS COUNTY—*Cont.*											
11	River Inhabitants, 3 mi. SSW. of Glendale	Small creek, shallow and fairly rapid. Bottom, rocky.	A		R				R			
12	Trout River at Lake Ainslie, Trout River	Stream, medium sized, deep and slow moving. Bottom mud.							R			
13	Lake Ainslie, 3 mi. S. of Scotsville	Lake large. Bottom, gravel and sand.		O					O			
14	Southwest Margaree River, 2 mi. NW. of Southwest Margaree	Stream medium sized. Bottom, sandy. This is the outlet of L. Ainslie.	A									
15	Northeast Margaree River, 1 mi. E. of Northeast Margaree	Stream medium sized. Bottom, gravel.	A									
16	Pond on branch of Northeast Margaree R., 7 mi. SW. of Northeast Margaree	Small, deep pond with muddy, narrow beaches.		A					C			
	VICTORIA COUNTY:											
17	Pond on branch of Northeast Margaree R., 2 mi. NW. of Finlayson	Small, deep pond with muddy, narrow beaches.		A					O			
18	Baddeck River, 3 mi. NW. of Baddeck	River medium sized. Bottom, gravel and sand.	R									
	CAPE BRETON COUNTY:											
19	McMullin Lake, on Mira River, 3 mi. W. of Victoria Bridge	Lake small. Bottom, rocks and gravel.		O			C		R			
	RICHMOND COUNTY:											
20	River Framboise, 3 mi. N. of Framboise	River small. Current rather rapid. Bottom, sand and rocks.	A									

	RICHMOND COUNTY—*Cont.*											
21	Brook at outlet of pond, 3 mi. E. of Loch Lomond Church	Very small brook. Bottom, muddy.							R			
22	Loch Lomond, middle lake at passage to lower lake	Lake large. Bottom, sand.							C			
23	Loch Lomond at outlet into Grand River	Lake large. Bottom, sand.							O			
24	Grand River, 6 mi. E. of town of Grand River	River small, Bottom, sand and rocks.	O									
25	Grand River, 2 mi. E. of town of Grand River	River small. Bottom, sand and rocks.	A									
	GUYSBOROUGH COUNTY:											
26	Pond, 1 mi. W. of Mulgrave	Pond small and deep. Bottom, rocky.							A			
27	Two Mile Lake, near Aspen	Lake medium sized but long and shallow. Bottom, sand and mud.		C								R
28	St. Mary River, Sherbrooke	River small and shallow. Bottom, rocky.	A	O		O						
	HALIFAX COUNTY:											
29	Musquodoboit River, 1.4 mi. NE. of Musquodoboit	Small ponded area of stream. Bottom, muddy and heavily vegetated.		A								
30	Musquodoboit River, 2 mi. E. of Elderbank	River medium sized, deep, and with small shoals.	O	A								
31	Musquodoboit River, 2 mi. S. of Crawford Bridge	River medium sized, deep and muddy. Unionids from muskrat middens.		A								C
32	Musquodoboit River, 2 mi. N. of Musquodoboit Harbour	River wider, shallow, and with mud and sandy shoals. Total hardness 28 p.p.m.		A	O		O					
33	Musquodoboit River, 1 mi. N. of Musquodoboit Harbour	River narrow, moderately deep and swift. Bottom, gravel and rocks.	C	O								
34	DeSaid Lake, 2 mi. N. of Eastern Passage	Medium-sized pond. Bottom mud, rocks, and wood fragments. Now filled by Halifax Airport.							C			
35	Morris Lake, 2 mi. E. of Imperoyal	Small lake with narrow outlet to ocean. Bottom, sandy.					O		O			
36	Fish Lake, 2 mi. S. of Waverly	Small lake with outlet to ocean. Bottom, rocky.		R	O		C	C				

Sta. No.	Locality	Habitat	*M. m. margaritifera*	*E. complanatus*	*A. undulata*	*A. varicosa*	*A. implicata*	*A. c. cataracta*	*A. c. brooksiana*	*S. undulatus*	*L. ochracea*	*L. r. radiata*
	HALIFAX COUNTY—*Cont.*											
37	Outlet of Fish Lake, 2 mi. S. of Waverly	Stream rather narrow. Bottom, rocky.		O	O		O	O				
38	Lake William, at outlet. Waverly	Medium-sized lake. Bottom, sand and rocks.		C	R		A	A				
39	Rocky Lake, 5 mi. NE. of Bedford	Medium-sized lake. Bottom, sandy.		O				O				
40	Small lake, 3 mi. E. of Lower Sackville	Collections made near and in outlet. Bottom, gravel and rocks.		C	O							
41	Sackville River, 1 mi. N. of Bedford	Medium-sized river, shallow. Current moderate. Bottom, rocky.	A									
42	Brine Lake, 1 mi. S. of French Village	Small, shallow lake. Bottom, mud, sand, and rocks.							A			
43	Gays River, Gays River	Small river. Bottom, sand and gravel.		C	C							
44	Brook flowing into Gays River, 4 mi. S. of Shubenacadie	Small stream flowing through cow pasture. Bottom, muddy.						R				
45	Outlet of Fletcher Lake, Wellington Station	Wide, slow-flowing stream. Bottom, mud. Unionids from muskrat middens.		A	R		C		C			C
46	Shubenacadie River, 1 mi. S. of Enfield	Medium-sized river, shallow and swift. Bottom, gravel.		A	O		C					
47	Outlet of Lower Egmont Lake. Lake Egmont	Outlet deep, slow moving. Banks, peat.		A				C				O
48	Long Lake at narrows, 3 mi. NW. of Preston	Small channel connecting two sections of Lake. Bottom, rocky.							O			

49	QUEENS COUNTY: Ten Mile Lake, 10 mi. NE. of Milton	Large lake. Sandy bottom.		O							
50	Ponhook Lake, 4 mi. SSE. of South Brookfield	Large lake. Sandy bottom.		C							
51	YARMOUTH COUNTY: Killam Lake, 4 mi. NE. of Port Maitland	Medium-sized lake. Bottom, sandy.		O					C		
52	Killam Lake, 7 mi. SSW. of Norwood	Medium-sized lake. Bottom, sandy.		A					C		
53	Cedar Lake, 6 mi. SW. of Norwood	Medium-sized lake. Bottom, sandy.		C					O		
54	DIGBY COUNTY: Cupits Lake, Hectanooga	Medium-sized pond, very shallow. Bottom, sand and rocks.		C					A		
55	Bonangs Lake	Medium-sized pond. Bottom, sandy.		A					R		
56	Lake, Sissaboo River System	Pond, about ¼ mi. in diameter.							A		
57	Lake, North Range			C				O			
58	ANNAPOLIS COUNTY: Annapolis River, Lawrencetown	River, wide and fairly swift. Apparently slightly polluted.		C		O					
59	Nictaux River, 2 mi. S. of Middleton	River, medium sized, quite rapid and deep. Water, turbid. Bottom, gravel.	R								
60	Springfield Lake, Springfield	Small lake. Bottom, sandy.		A							
61	KINGS COUNTY: Lake Torment outlet, 1 mi. below Lake Torment Dalhousie East	Medium-sized creek. Bottom, sand and rocks, heavily vegetated.		R				R			
62	Gaspereau River, 2 mi. S. of South Alton	River, narrow and rapid. Bottom, sand and boulders.					O				
63	Gaspereau River, ½ mi. W. of Whiterock Mills	River narrow. Current moderate. Bottom, gravel, sand and mud.					C				

Sta. No.	Locality	Habitat	*M. m. margaritifera*	*E. complanatus*	*A. undulata*	*A. varicosa*	*A. implicata*	*A. c. cataracta*	*A. c. brooksiana*	*S. undulatus*	*L. ochracea*	*L. r. radiata*
	HANTS COUNTY:											
64	Cornwallis River, 1 mi. S. of Waterville	River, narrow and deep. Bottom, mud and sand with shoals.					C					
65	Kennetcook River, 3 mi. E. of Clarksville	River wide, shallow, and with sand shoals. Total hardness 28 p.p.m.		A	O							
66	Pond, Mt. Uniack, 20 mi. N. of Halifax	Pond large. Bottom, mud and rocks.						O				
	COLCHESTER COUNTY:											
67	Stewiacke River, 5 mi. E. of Stewiacke	River wide, shallow and swift. Bottom, gravel.	A	A	R	R						
68	Tatamagouche River, 2 mi. SW. of Tatamagouche	River moderately wide, shallow, and with gravel bottom.	A									
69	Baird Brook, Crow Mills	Collections made in dammed area. Bottom, sand.						C				
70	Beaver Brook, 1 mi. N. of Belmont	Small brook. Bottom, sand and gravel.	A									
71	Chiganois River, 3 mi. SW. of Belmont	River medium sized and shallow. Bottom, gravel and rocks.	O									

SYSTEMATIC SECTION[1]

Superfamily **UNIONACEA**

Family *MARGARITIFERIDAE*

Genus MARGARITIFERA Schumacher, 1817

Margaritifera margaritifera margaritifera (Linn.)

Plate I, figs. 1 to 4

Mya margaritifera Linn., 1758: Systema Naturae, 10th ed., p. 671 (type locality: Europe).

Description

This unionid is easily distinguished by its large size (up to 6 inches long) and elongate and often arcuate shape. Other prominent characteristics are its black periostracum, whitish nacre, heavy pseudocardinal hinge teeth, and obsolete or absent lateral teeth.

Distribution

M. m. margaritifera is the only freshwater mussel that occurs in Europe and Asia as well as in North America. In this continent it is known from both sides of the Gulf of St. Lawrence south to Pennsylvania and from Anticosti Island and Newfoundland. In the West the subspecies (*falcata* Gould) is found occurring from Alaska to New Mexico. Both the typical species and the subspecies are absent from the central part of North America.

During this survey *margaritifera* was collected at twenty-three stations (*see* table). These are plotted on Map I as filled-in circles. Other records from Nova Scotia are: East River, Pictou County (Nat. Mus. Canada) and "Rivers in Annapolis [County]" (Willis, 1857).

Ecology

Jones's (1877) statement that in Nova Scotia the species occurs in lakes as well as in streams is no doubt incorrect. The authors have collected *margaritifera* at over one hundred different localities in northeast North America and have found it only in streams, never in lakes or ponds. All streams found to contain this species have exhibited similar ecological characteristics, i.e., moderate to quite rapid current, and sand, gravel, or rocky substrate. Although only a few water samples were analysed, low water hardnesses (less than 50 p.p.m. total hardness) were found in each case. This agrees with statements in the literature that the species occurs only in soft water. Hendelberg (1960) has shown that this species sometimes lives to be over 100 years old.

Murphy (1942) has shown that both the brown and rainbow trout function as hosts for the western subspecies *falcata*. Clarke and Berg (1959) have suggested that the native brook or eastern speckled trout, *Salvelinus fontinalis* (Mitchell), is the probable host for *margaritifera* s.str. Both *S. fontinalis* and *M. m. margaritifera* are unusually abundant and wide-

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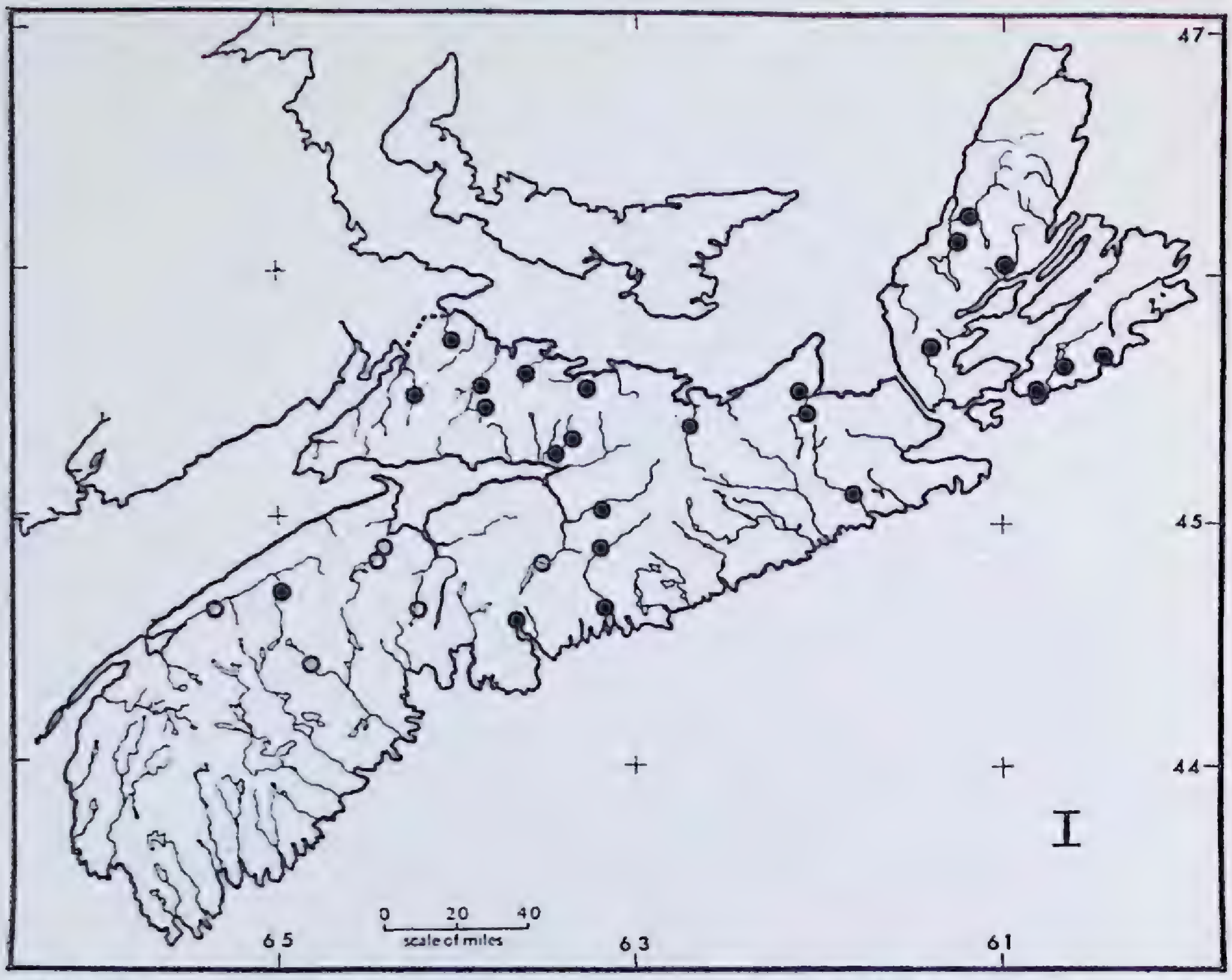
[1] For more complete information on the following species *see* Simpson, 1914; Ortmann, 1919; and Clarke and Berg, 1959.



MAP I. *Margaritifera margaritifera margaritifera.* Filled-in circles represent stations at which the species was found. Open circles represent negative stations which appeared ecologically suitable for the species.

spread in Nova Scotia and occur in identical habitats. Also, since *fontinalis* is the only widely distributed trout in the province, it is very probably the principal host for the glochidia of *margaritifera.* The only other generally distributed salmonid in Nova Scotia is *Salmo salar* Linn., the Atlantic salmon, an anadromous fish that does not occur as far inland elsewhere in North America as does *margaritifera.*

This species is the *Margaritana margaritifera* of authors. The name *Margaritana* has been placed on the Official List of Rejected and Invalid Generic Names in Zoology (1958) by the International Commission on Zoological Nomenclature.

Subfamily UNIONINAE

Genus ELLIPTIO Rafinesque, 1819

Elliptio complanatus (Solander)

Plate I, figs. 5, 6; Plate IV, figs. 7, 8

Mya complanata Solander, 1786: Portland Catalogue, p. 11, lot 2190 (type locality: Maryland). Johnson (1948) has restricted the type locality to Potomac River, Washington, D.C.

Description

Although exceedingly variable, *Elliptio complanatus* is quite easy to recognize. The shell is medium sized (up to 5 inches long), rather compressed, subelliptical to subrhomboid in shape, and of medium thickness. It has a dark and usually rayless periostracum, prominent pseudocardinal and lateral hinge teeth, and nacre that is often purple but occasionally white or salmon coloured.

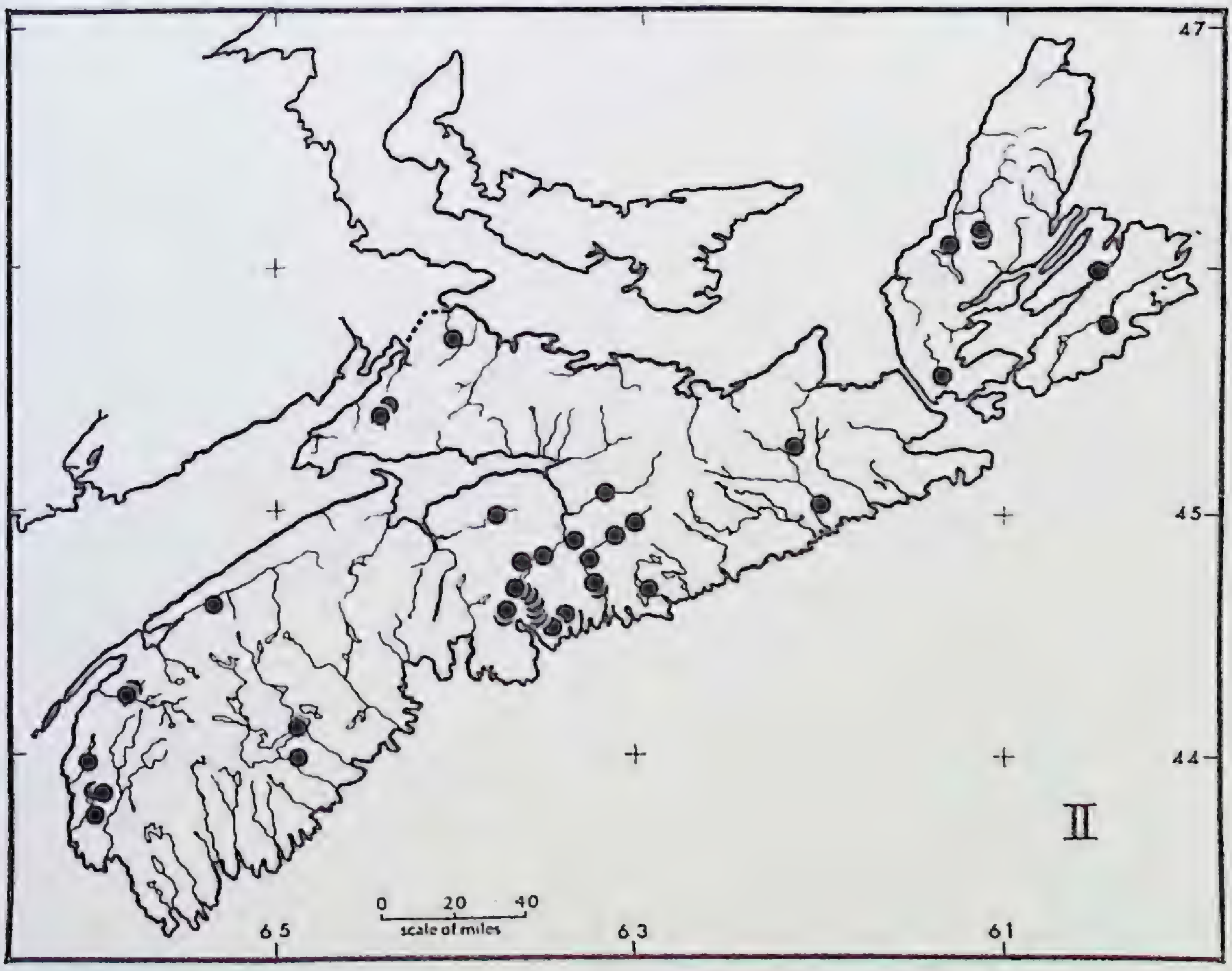
Distribution

This species is found in the Atlantic Drainage from the Gulf of St. Lawrence to Georgia and in the St. Lawrence Drainage east of eastern Lake Erie. It also occurs in Lake Huron and Lake Superior, in some of their tributaries, and in parts of the Hudson Bay Drainage. Details of its northern distribution remain to be worked out.

During this survey *E. complanatus* was collected at thirty-seven stations (*see* table). It has also been taken in Sydney River Lake, Ship Harbour Lake, and at the narrows in Grand Lake, Nova Scotia (all, Nat. Mus. Canada). All these records are plotted on Map II.

Ecology

In Nova Scotia, as elsewhere, this species is found in lakes, ponds, rivers, and streams, and on nearly all kinds of substrates. Only very small



Map II. *Elliptio complanatus*. Positive localities are plotted as filled-in circles.

brooks appear to be unsuitable. It is very common and is usually the dominant species where it occurs.

According to Lefevre and Curtis (1912) and Matteson (1948), the yellow perch, *Perca flavescens* (Mitchill), is the host for *E. complanatus*. Livingstone (1951) has stated that *P. flavescens* does not occur in Cape Breton Island, however; and the presence of *E. complanatus* there poses a problem. Either another host fish is involved or *P. flavescens* does occur there but was not detected.

Subfamily ANODONTINAE

Tribe ALASMIDONTINI

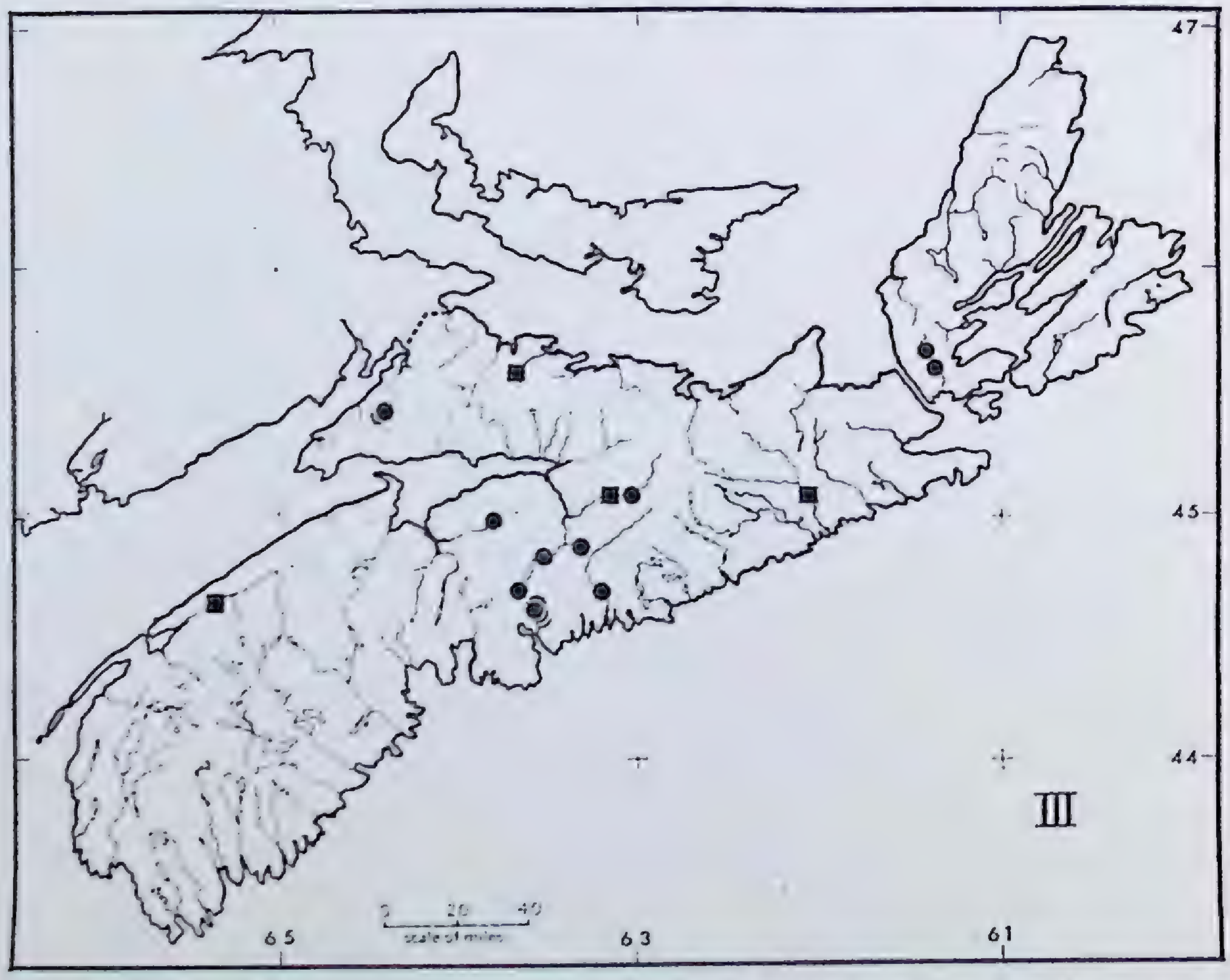
Genus ALASMIDONTA Say, (1818)

Subgenus ALASMIDONTA, s.str.

Alasmidonta (Alasmidonta) undulata (Say)

Plate III, figs. 3, 4

Monodonta undulata Say, 1817: Nicholson's Encyclopedia, 1st. ed., *2*, pl. 3, fig. 3 (type locality: Delaware and Schuylkill rivers).



MAP III. *Alasmidonta undulata* and *A. varicosa*. Positive localities for *A. undulata* are plotted as filled-in circles. Positive localities for *A. varicosa* are plotted as filled-in rectangles.

Description

A. undulata is well characterized by its small size (up to 3 inches long); short, subtriangular shape; dark or rayed periostracum; and prominently thickened anterior. The pseudocardinal hinge teeth are well developed and stubby, but the lateral teeth are nearly or entirely absent. The beak sculpture is unusually coarse and heavy.

Distribution

This species is distributed in the Atlantic Drainage from the Gulf of St. Lawrence to North Carolina and in the St. Lawrence River and its tributaries east of Lake Erie. In Nova Scotia it was found at twelve stations, all in the central part of the province. These stations are plotted on Map III.

Ecology

Alasmidonta undulata occurs in lakes and in rivers usually on a sandy bottom. It is sporadic in its occurrence and almost never abundant. The authors have found it dominant at only a few localities in northeastern North America. The host fish is unknown.

Subgenus DECURAMBIS Rafinesque, 1831

Alasmidonta (Decurambis) varicosa (Lamarck)

Plate III, figs. 5, 6

Unio varicosa Lamarck, 1819: Anim. sans Vertèbres, *6*: 68 (type locality: Schuylkill River near Philadelphia, Pennsylvania).

Description

The small size (up to 2½ inches long), subovate shape, inflated posterior ridge, corrugated posterior slope, and characteristic periostracum and hinge teeth clearly distinguish this species. The periostracum is more or less distinctly rayed and is usually lighter coloured anteriorly than posteriorly. Pseudocardinal hinge teeth are small but usually distinct. Lateral teeth are absent.

Distribution

A. varicosa is found in the Atlantic Drainage from Nova Scotia and New Brunswick to South Carolina. The authors have found it at only four stations in Nova Scotia. These localities have been plotted on Map III.

Ecology

A. varicosa occurs only in moderate to rapidly flowing streams, often in riffles or rapids, and in sand or among gravel or rocks. Its usual associates are *Margaritifera m. margaritifera* and *Elliptio complanatus*. The host fish is unknown.

Tribe ANODONTINI

Genus ANODONTA Lamarck, 1799

Anodonta implicata Say

Plate II, figs. 1, 2

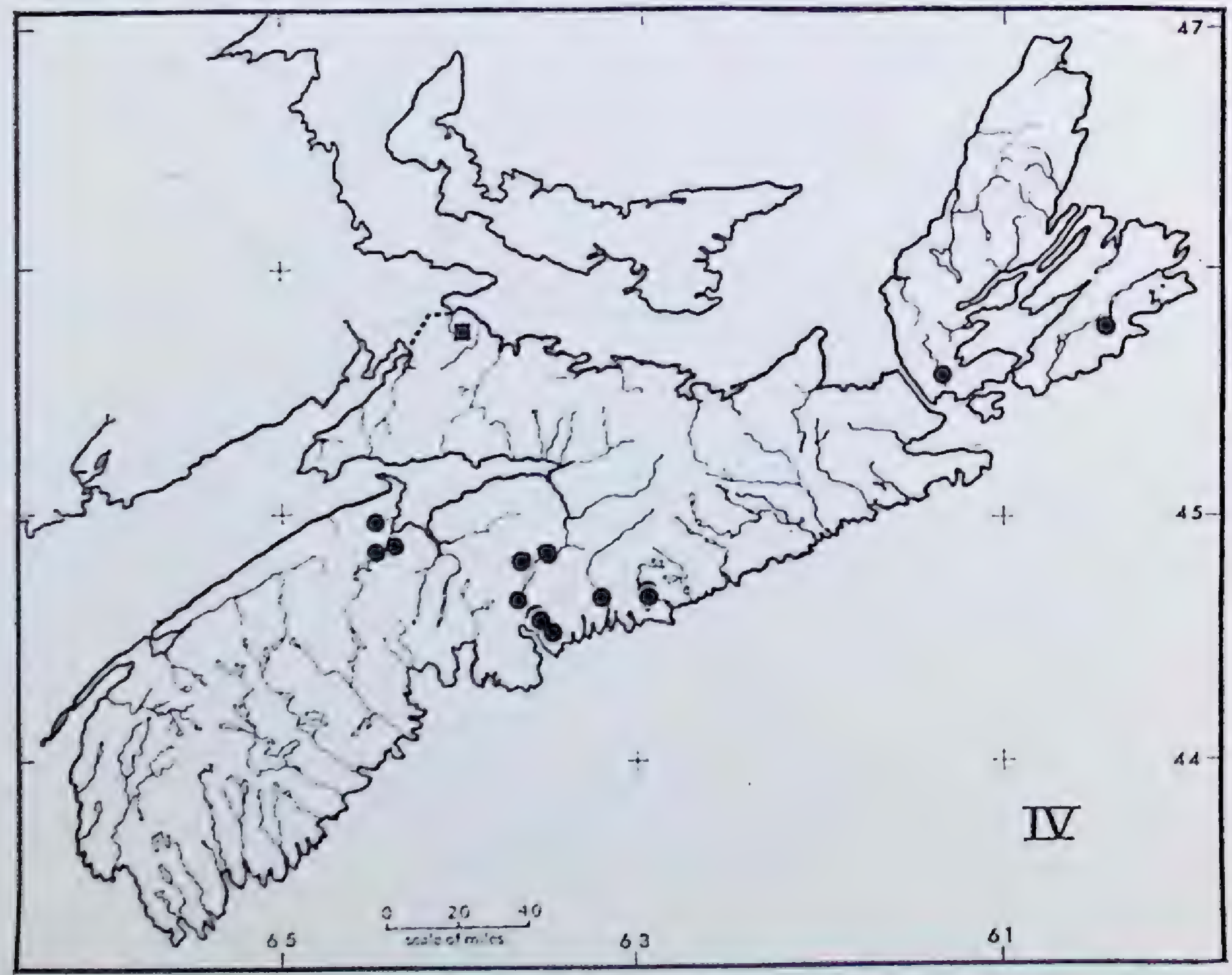
Anodonta implicata Say, 1829: New Harmony Dissem., *2,* no. 22, p. 340 (type locality: Danvers, Massachusetts, U.S.A.). Neotype selected by Johnson, 1946 (neotype locality: Agawam River, Plymouth, Massachusetts).

Description

A. implicata may be distinguished from other species by its large size (up to 6½ inches long), by its elongate-elliptical shell which is prominently thickened anterior-ventrally, and by the complete absence of hinge teeth. The periostracum is usually heavy, yellowish, brownish, or black, and is not rayed except obscurely in occasional young specimens. The nacre is normally salmon coloured or pinkish, sometimes white or bluish.

Distribution

This species is recorded with certainty only from Nova Scotia south to South Carolina. During the present survey it was collected at 12 stations. These have been plotted on Map IV.



MAP IV. *Anodonta implicata* and *Strophitus undulatus*. Positive localities for *A. implicata* are plotted as filled-in circles. The single positive locality for *S. undulatus* is plotted as a filled-in rectangle.

Ecology

The host fish for *A. implicata* is the alewife (or gaspereau), *Alosa pseudoharengus* (Wilson), a marine fish that migrates into coastal rivers and lakes in the spring to spawn. *Anodonta implicata* is therefore restricted to coastal regions frequented by its host. There it occurs on sand or gravel substrates, rarely on mud. Although *A. pseudoharengus* is also landlocked in the Great Lakes and in the Finger Lakes of New York, no authentic specimens of *A. implicata* have been seen from those areas.

Anodonta cataracta cataracta Say

Plate II, figs. 5, 6

Anodonta cataracta Say, 1817: Nicholson's Encyclopedia, 1st ed., *2,* pl. 3, fig. 4 (type locality not specified).

Description

The shell of *Anodonta cataracta cataracta* is medium to large (up to 6 inches long), thin, inflated, and without hinge teeth. The periostracum is green or greenish brown. Two broad green rays are often present on the posterior slope. It may be distinguished from the closely related *A. cataracta brooksiana* by its beak sculpture, which is typically double-looped in *cataracta* s.str. but concentric and single-looped in *brooksiana*. (*See* "Remarks" under *brooksiana.*)

Distribution

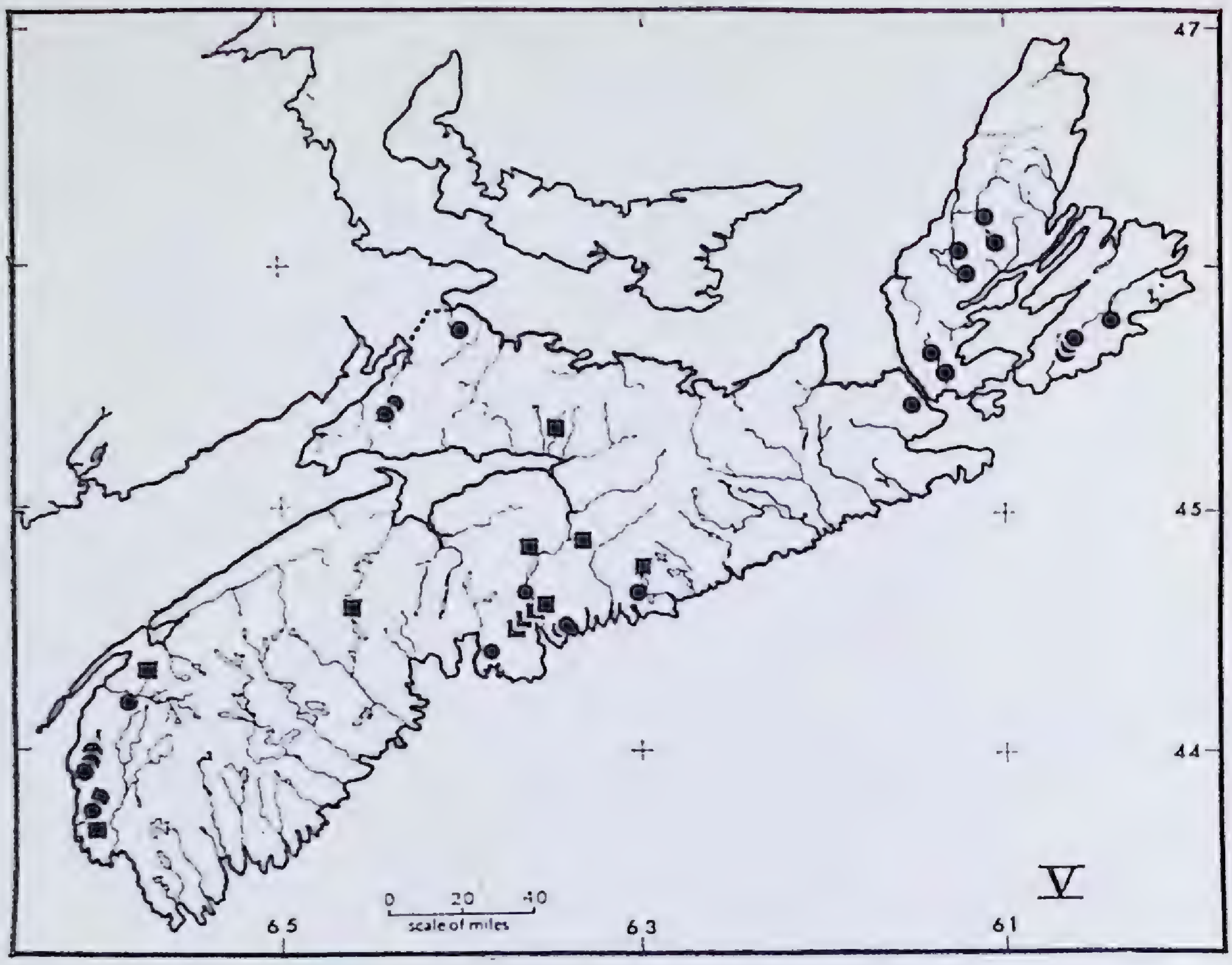
Typical *A. cataracta* occurs in the Atlantic Drainage from the lower St. Lawrence System to North Carolina. Specimens closely related to this species also occur in Michigan, in parts of the Hudson Bay Drainage, and from South Carolina to Alabama. Details of its northern and southern distribution require further investigation.

During this survey, typical specimens of *cataracta* were collected at seven stations. The National Museum of Canada also possesses a specimen from Yarmouth, Nova Scotia. These records have been plotted on Map V as filled-in rectangles.

Ecology

This species occurs in lakes and ponds and in large and small, usually slow-moving streams. Although sand and mud are the more frequently occupied substrates, gravel and rocky areas are also sometimes inhabited. In Nova Scotia it is usually the only unionid found in soft, muddy habitats.

Host fish of *A. c. cataracta* are unknown. However, zoogeographic and habitat similarities between that species and the brown bullhead (*Ictalurus nebulosus nebulosus* Le Sueur) together with the unusual ability of both species to withstand the low oxygen concentrations characteristic of semi-stagnant, muddy habitats suggest a possible parasite-host relationship.



Map V. *Anodonta cataracta brooksiana* and *A. c. cataracta.* Positive localities for *A. c. brooksiana* are plotted as filled-in circles. Positive localities for *A. c. cataracta* are plotted as filled-in rectangles.

Anodonta cataracta brooksiana van der Schalie

Plate II, figs. 3, 4

Anodonta brooksiana van der Schalie, 1938: Ann. Carnegie Mus., *27*: 167–169. pl. 16, fig. 1 and 2 (type locality, Sprout Pond Arm, Ferryland District, Newfoundland).

Distribution

The shell of *brooksiana* is of medium size (up to nearly 5 inches long), thin, elliptical, and inflated. The beaks and posterior slope are low, and a poorly defined wing is present. The periostracum is straw yellow, crossed by numerous fine green rays, and on the posterior slope two prominent green rays are usually present. The nacre is thin, uniform in thickness, with a bluish-silvery hue. Hinge teeth are completely absent.

The most distinctive character of *brooksiana* is the beak sculpture. In the original description (van der Schalie, l.c.) this was described as "consisting of numerous (8–12) more or less irregularly concentric, corrugated folds which extend well out on the disc; the first two or three folds somewhat double-looped while the others are irregular and often appear to anastomose." As such, it differs from the beak sculpture of other anodontas found in eastern Canada which is "characteristically double-looped and nodular" (Van der Schalie, l.c.).

Distribution

In addition to Newfoundland, this form has been recorded from New Brunswick (Athearn, 1961). Specimens agreeing with the above description were also collected during this survey at twenty-five stations in Nova Scotia. These stations are plotted on Map V.

Ecology

A. c. brooksiana occupies habitats similar to those occupied by *cataracta* s. str., i.e., lakes, ponds, rivers, and streams, and is found on a variety of substrates. Like *cataracta,* the host fish of *brooksiana* are unknown.

Remarks

Through the kindness of Dr. Henry van der Schalie, University Museums, University of Michigan, we have been able to study paratype specimens of *Anodonta brooksiana*. These specimens exhibit the concentric beak sculpture which is characteristic of that form. Examination of a number of lots of *A. cataracta* from various localities in northeastern United States has indicated the presence of similar concentric beak-sculpture in occasional specimens of *cataracta*. This character appears to be more frequent in northern populations, however. On the basis of present information the form *brooksiana* does not correspond with the accepted definition of a species. Its status needs careful re-evaluation, but in this paper it is regarded as a subspecies of *cataracta* s. str.

Genus STROPHITUS Rafinesque, 1820

Strophitus undulatus (Say)

Plate III, figs. 7, 8

Anodonta undulata Say, 1817: Nicholson's Encyclopedia, Philadelphia, 1st ed., 2: 20–21, pl. 3, fig. 6 (type locality not specified but presumably near Philadelphia, Pennsylvania).

Description

This species is medium-sized (up to 3½ inches long) and fairly thin and has a rather smooth and shining yellowish brown to black periostracum. Pseudocardinal hinge teeth are usually indicated by slight to clearly visible swellings just anterior to the beaks of each valve. Lateral hinge teeth are completely absent. The nacre is bluish white with yellowish or salmon suffusions near the beaks, and is bordered at the edge of the valves with olive green or greenish brown. The vestigial hinge teeth and characteristic nacre are the best conchological characteristics in this species.

Distribution

S. undulatus is widely distributed and occurs from Lake Huron eastward in the St. Lawrence Drainage, south to North Carolina in the Atlantic Drainage, and throughout the Ohio-Mississippi-Missouri Drainage. In Nova Scotia it was found at only one locality, the Tidnish River, 10 mi. NE. of Amherst (*see* Map IV).

Ecology

S. undulatus occurs with greatest frequency in small rivers and creeks on fine gravel, sand, or mud. Occasionally it also occurs in lakes. The largemouth black bass, *Micropterus salmoides* (Lacépède), and the northern creek chub, *Semotilus atromaculatus* (Mitchill), have served, under experimental conditions, as satisfactory hosts for the glochidia of *S. undulatus*. Only the latter fish occurs in Nova Scotia (Livingstone, 1951).

This species is the *Strophitus rugosus* (Swainson) of authors.

Subfamily *LAMPSILINAE*

Genus LAMPSILIS Rafinesque, 1820

Lampsilis ochracea (Say)

Plate IV, figs. 3, 4

Unio ochraceus Say, 1817: Nicholson's Encyclopedia *2*, pl. 3, fig. 8 (type locality: Delaware and Schuylkill rivers).

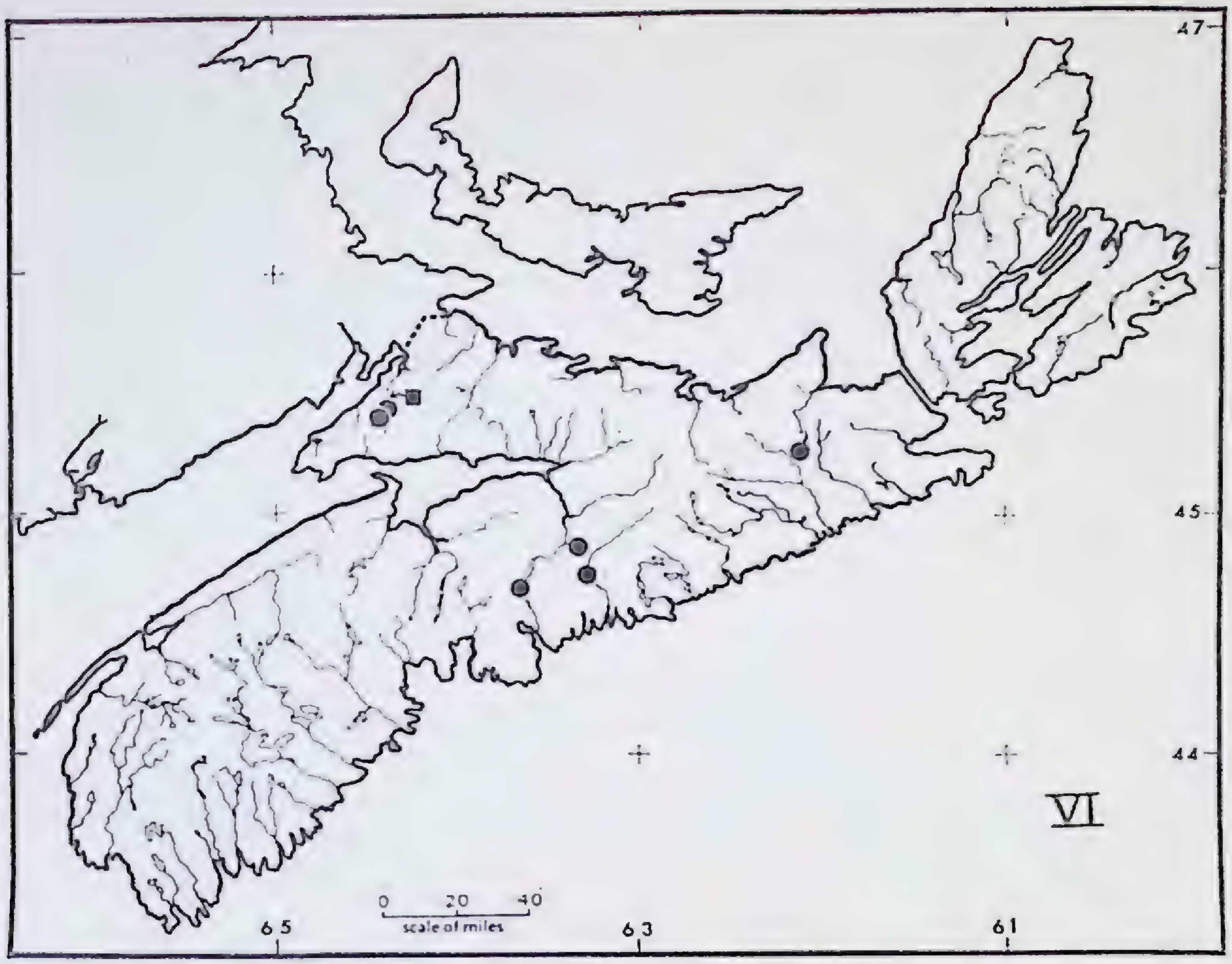
Description

L. ochracea is medium sized (up to 3½ inches long), subovate and rather thin. Sexual dimorphism is prominent: females are enlarged posteriorly, but males are not. The periostracum is brownish and with or without rays. Pseudocardinal and lateral teeth are both well developed but narrow. The nacre is white, bluish white, or tinged with pink or salmon.

Distinguishing characters between this species and other lampsilids, i.e., *L. cariosa* (Say) and *L. radiata radiata* (Gmelin), are as follows. In *cariosa* the shell and hinge teeth are thickened; the periostracum is yellowish, and when rays are present they are confined to the posterior slope only. In *ochracea* the shell and hinge teeth are thin; the periostracum is brownish; and when rays are present, they are distributed over the whole surface. *L. radiata* may be distinguished by the absence of prominent sexual dimorphism and the more heavily thickened shell. Also, the interdentum in *ochracea* is thin and compressed, but in *cariosa* and *radiata* it is thick and heavy. *L. cariosa* has not been found in Nova Scotia.

Distribution

This species is quite sporadic in its distribution. It has been recorded from New Brunswick (Athearn, 1961) south to the Ogeechee River, Georgia. In Nova Scotia it was found only at station 2: the River Hebert at Newville. This station is plotted on Map VI.



MAP VI. *Lampsilis radiata radiata* and *L. ochracea*. Positive localities for *L. r. radiata* are plotted as filled-in circles. The single positive locality for *L. ochracea* is plotted as a filled-in rectangle.

Ecology

L. ochracea occurs in ponds, canals, and slow-flowing rivers on sandy or muddy bottoms. It is most abundant in ponds near the sea-coast. The host fish is unknown.

Lampsilis radiata radiata (Gmelin)

Plate IV, figs. 5, 6

Mya radiata Gmelin, 1792: Systema Naturae, 13th ed., p. 3220 (type locality, Virginia).

Description

The shell of this species is medium sized (up ot 4½ inches long), subelliptical, thickened anteriorly, and has well-developed pseudocardinal and lateral teeth. The periostracum is roughened by close, concentric wrinkles; is yellowish, greenish, brownish, or blackish in colour; and has darker rays generally distributed over the shell but prominent only in young or light-coloured individuals. The nacre is white, bluish white, or tinted with salmon or pink.

Distribution

L. r. radiata ranges from Lake Ontario through the lower St. Lawrence Drainage and south in the Atlantic Drainage to North Carolina. A closely related inland subspecies, *L. r. siliquoidea* (Barnes), also occurs in the St. Lawrence Drainage, and intergrades with *radiata* in that region are common (Clarke and Berg, 1959).

During this survey *radiata* was collected at only six stations. These stations have been plotted on Map VI.

Ecology

This species is relatively common throughout most of its range. It occurs in lakes and rivers on substrates of gravel or sand and occasionally on mud. The host fish is unknown. It may be significant, however, that the yellow perch, *Perca flavescens* (Mitchill), and the smallmouth bass, *Micropterus dolomieui dolomieui* Lacépède, have both been implicated as hosts for *L. r. siliquoidea*, and both occur in Nova Scotia.

ACKNOWLEDGMENTS

The authors wish to thank Mr. D. K. Crowdis, Director of the Nova Scotia Museum of Science, and Dr. W. J. Clench, Curator of Mollusks, Museum of Comparative Zoology, for the privilege of examining specimens in those institutions. Thanks are also extended to Messrs. F. R. Cook and D. E. McAllister of the National Museum staff for reading the manuscript and offering useful comments.

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PLATE I

Figs. 1, 2. *Margaritifera margaritifera margaritifera,* adult
Figs. 3, 4. *M. m. margaritifera,* sub-adult
Figs. 5, 6. *Elliptio complanatus,* adult
Figs. 7, 8. *Ligumia nasuta,* adult

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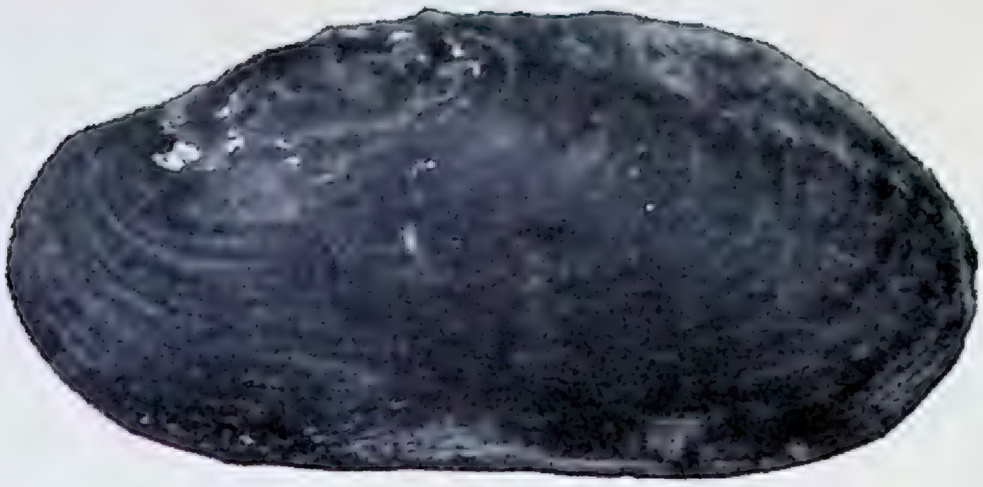
PLATE I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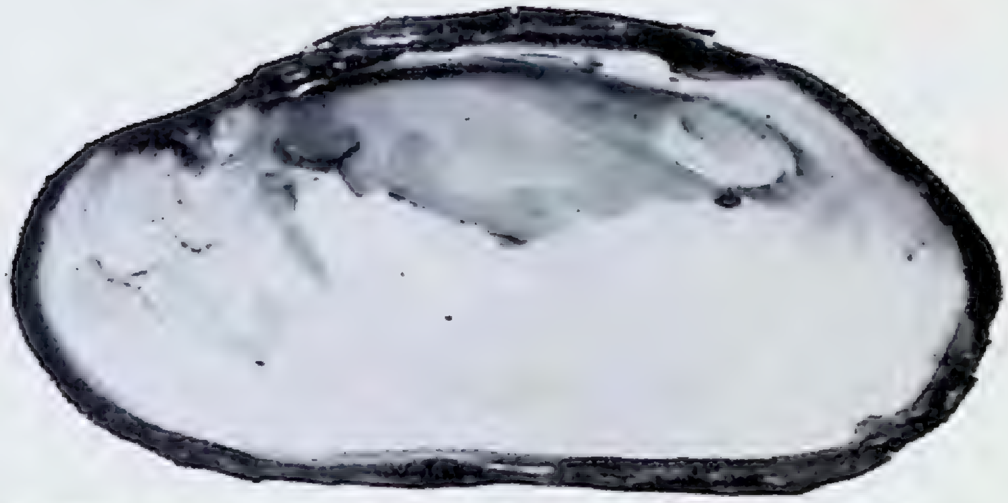
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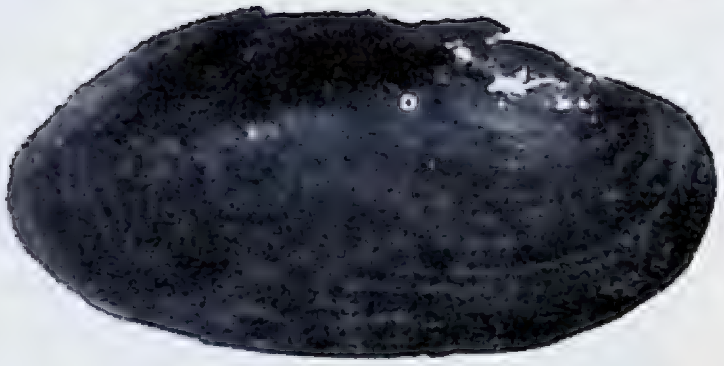
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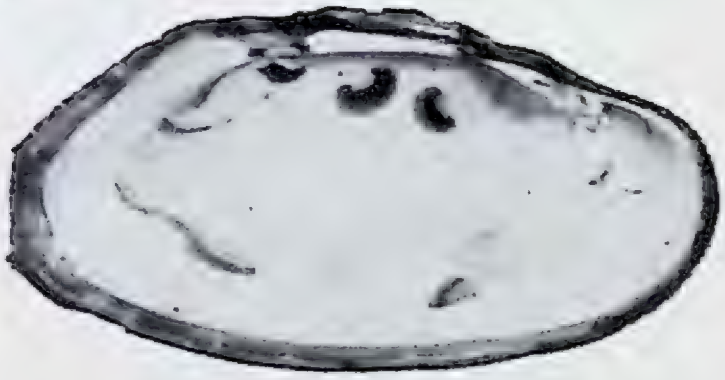
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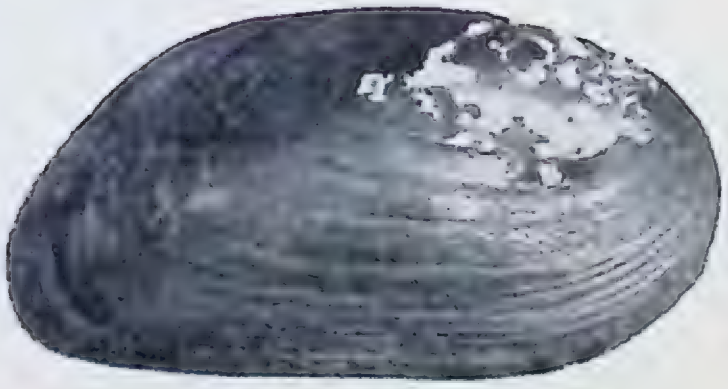
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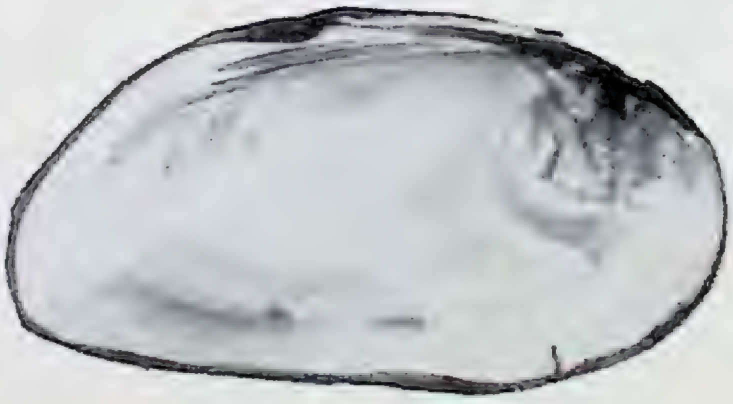
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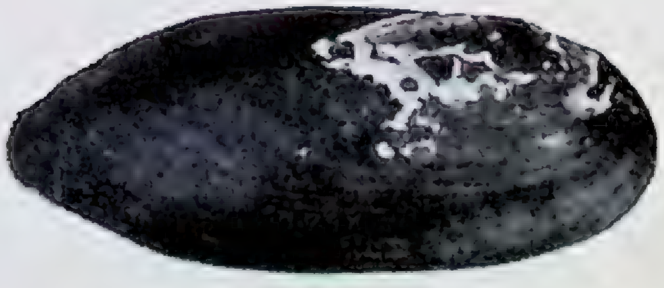
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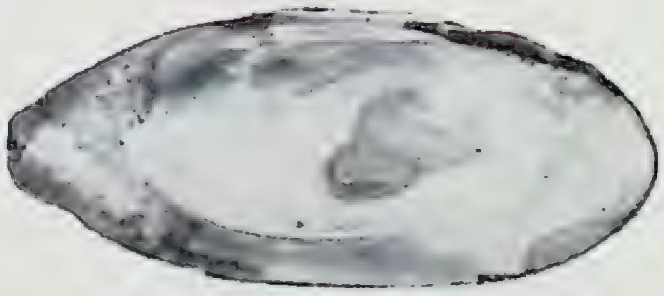
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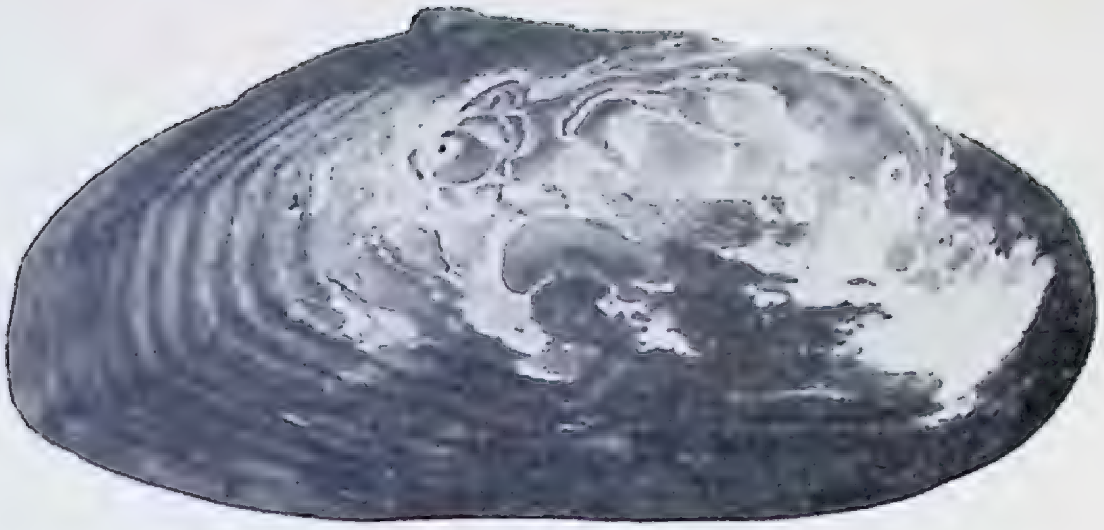
PLATE II

Figs. 1, 2. *Anodonta implicata,* adult
Figs. 3, 4. *Anodonta cataracta brooksiana,* adult
Figs. 5, 6. *Anodonta cataracta cataracta,* adult

All figures .69X

PLATE II



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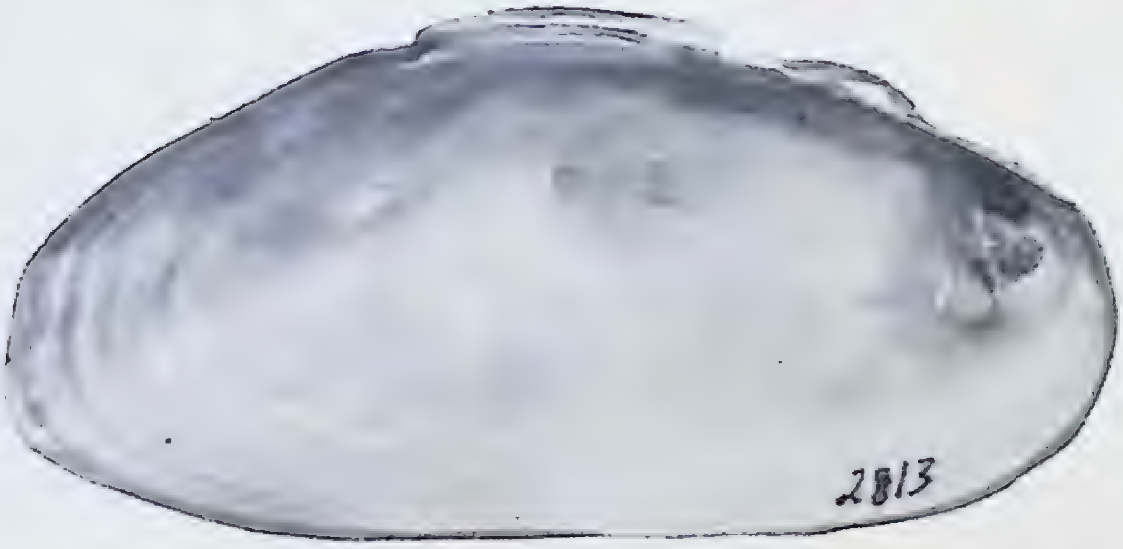

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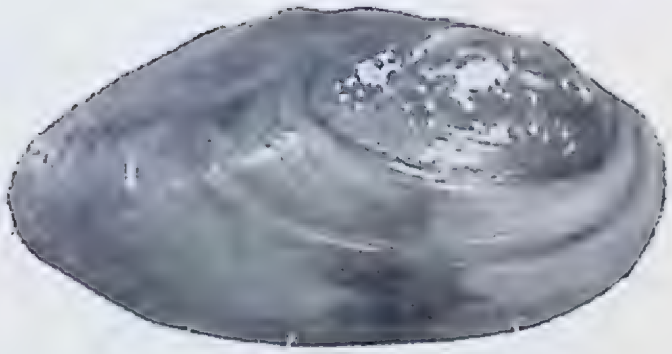

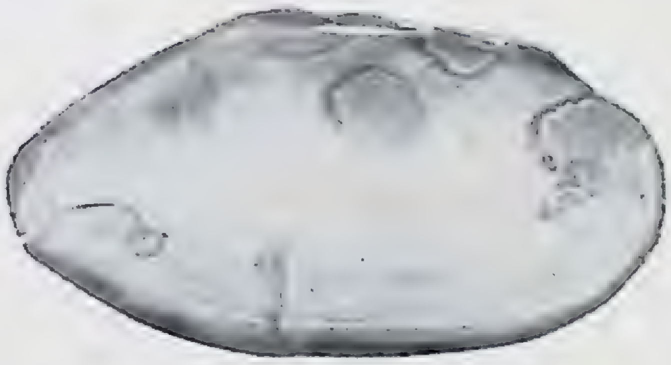

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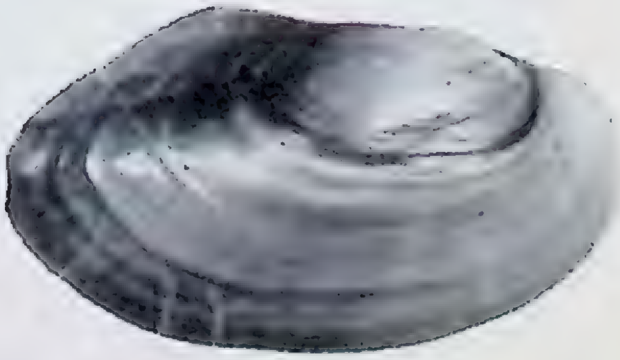

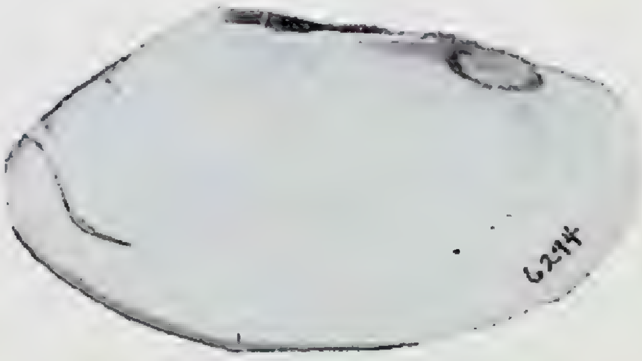

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PLATE III

Figs. 1, 2. *Alasmidonta heterodon,* adult
Figs. 3, 4. *Alasmidonta undulata,* adult
Figs. 5, 6. *Alasmidonta varicosa,* adult
Figs. 7, 8. *Strophitus undulatus,* sub-adult

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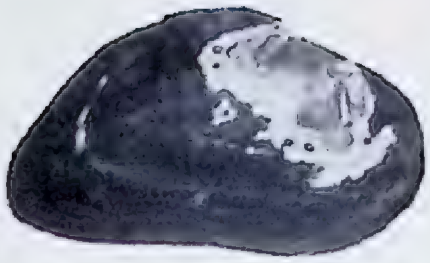
PLATE III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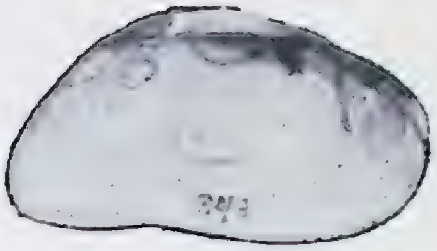
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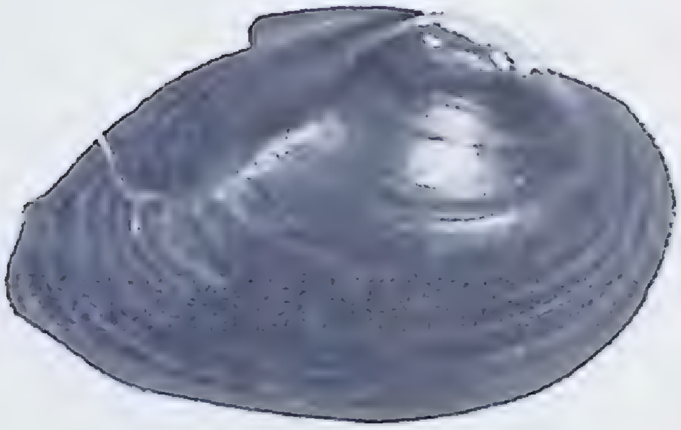
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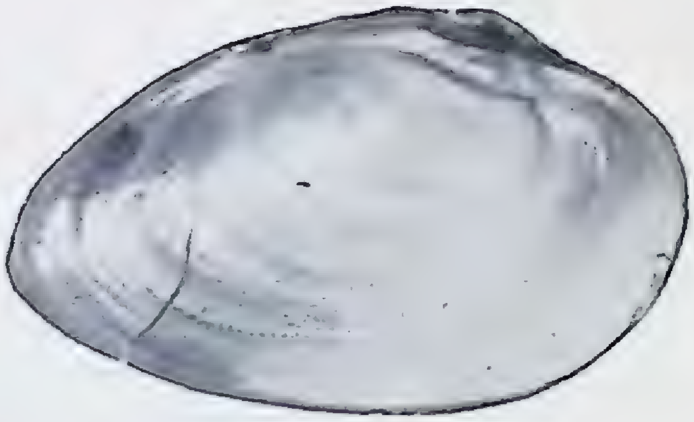
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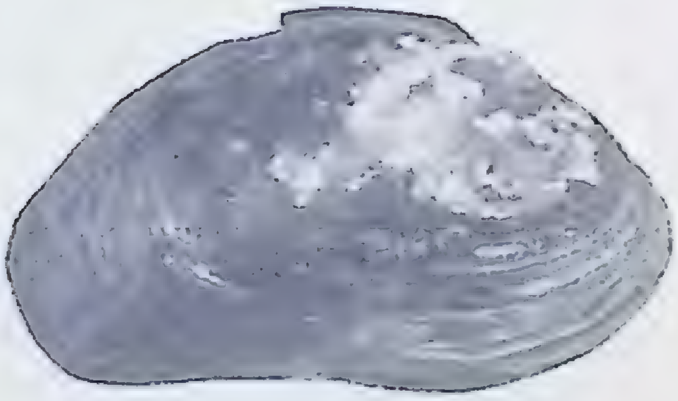
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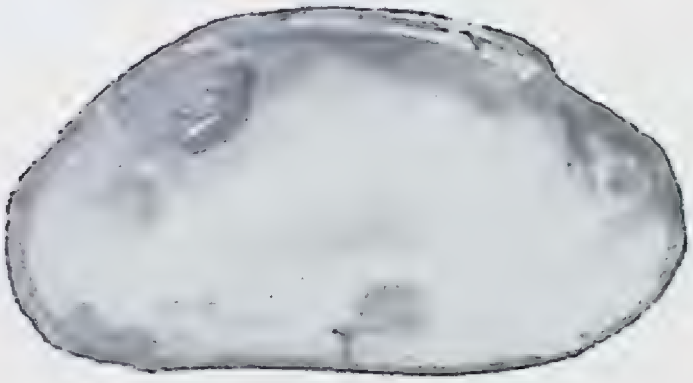
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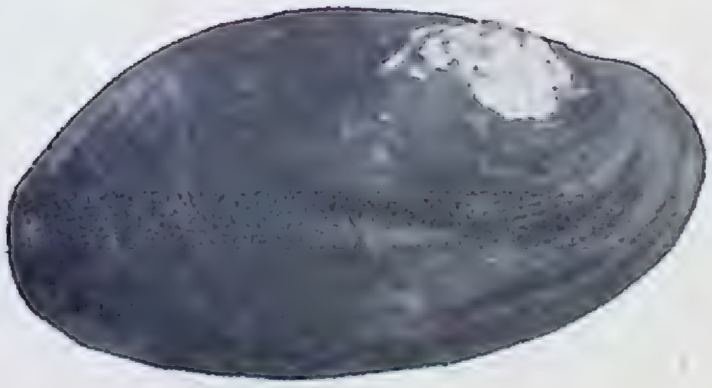
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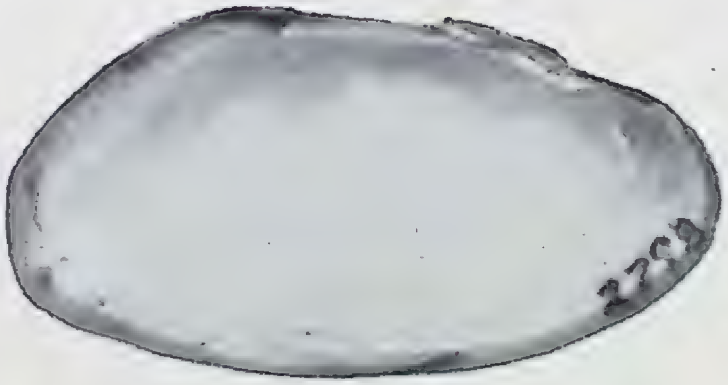
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PLATE IV

Figs. 1, 2. *Lampsilis cariosa,* juvenile male
Figs. 3, 4. *Lampsilis ochracea,* adult female
Figs. 5, 6. *Lampsilis radiata radiata,* adult female (?)
Figs. 7, 8. *Elliptio complanatus,* adult

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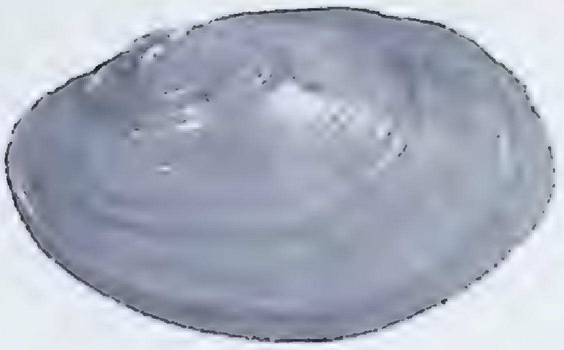
PLATE IV



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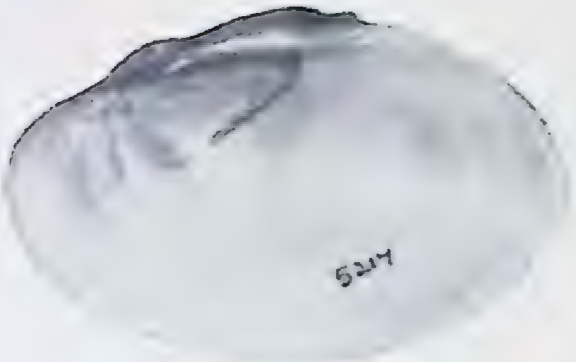

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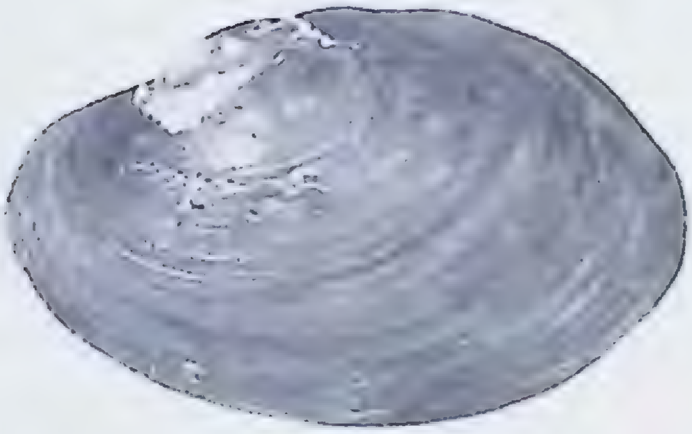

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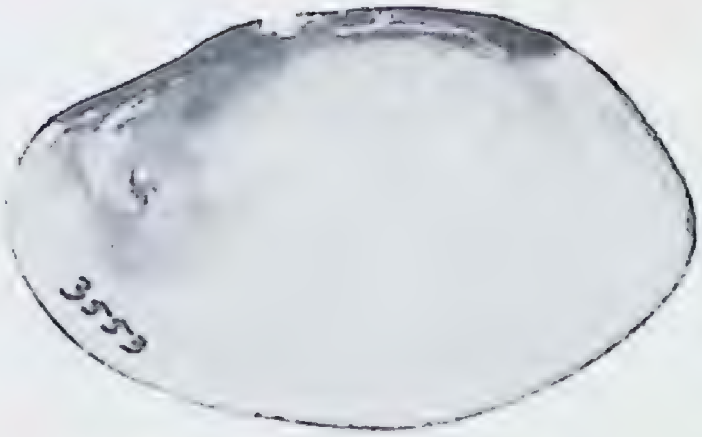

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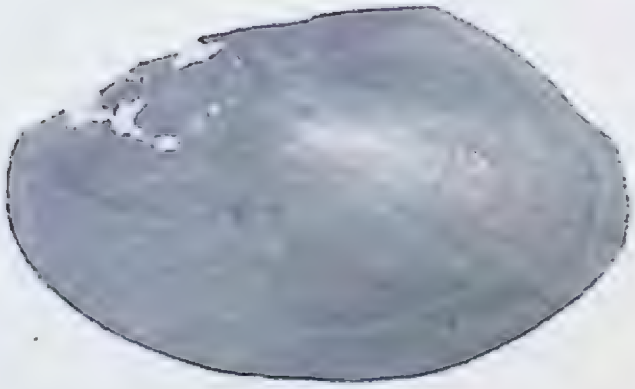

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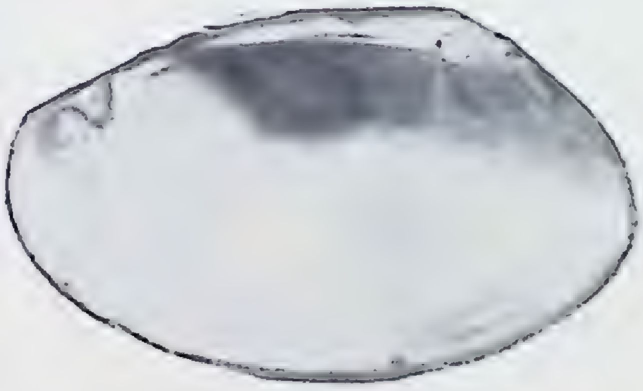

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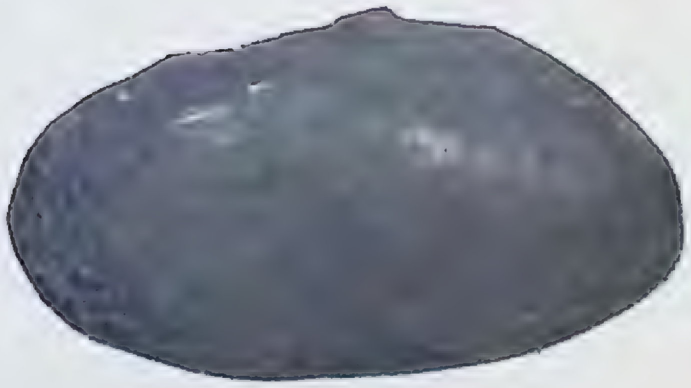

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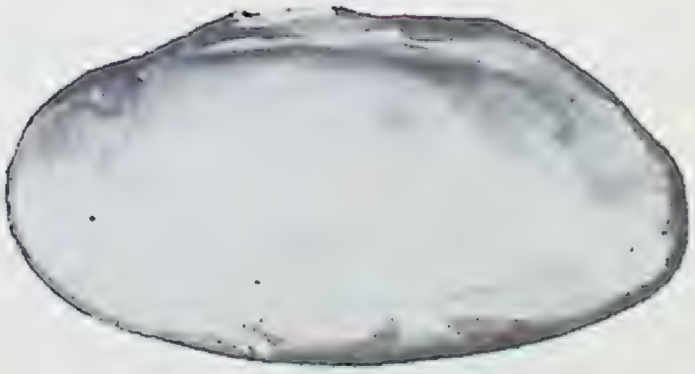

8

STUDIES ON LITTORAL MARINE ARTHROPODS FROM THE BAY OF FUNDY REGION

By E. L. Bousfield

During the period June 16 to August 22, 1958, the writer conducted a survey of intertidal and shallow-water marine invertebrates of the Bay of Fundy region, Eastern Canada. The material and station data from Minas Basin and Minas Channel have been included in a previous report (Bousfield and Leim, 1960). Records of molluscs have been embodied in a general account on Canadian Atlantic sea shells (Bousfield, 1960). Herewith is presented a list of the crustaceans and other arthropods collected intertidally in the Bay of Fundy proper, with a discussion of zoogeographical and ecological affinities of the fauna. A total of 68 stations were visited, at 32 of which marine specimens were collected and hydrographical measurements made (*see* Figure 1; Table 1). Also included are selected records of crustaceans obtained in 1950 from the St. John estuary and other Fundy localities (Figure 1; Table 2; and Bousfield, 1952, Figure 12).

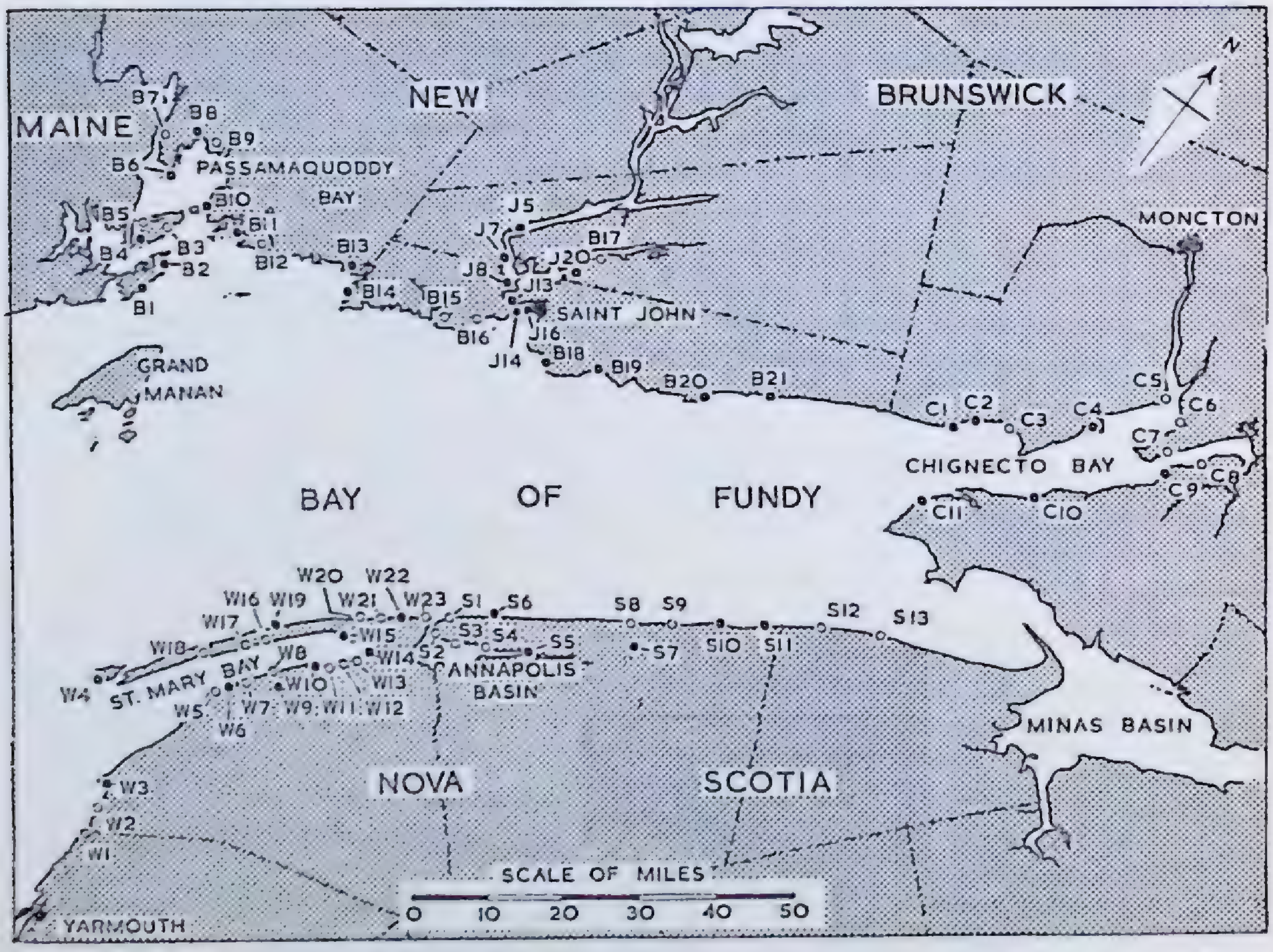

Figure 1. Localities visited in the Bay of Fundy region, 1958, and the St. John Estuary, 1950.

● —Specimens collected and/or hydrographical observations made.

○—Ecological observations only.

The Bay of Fundy is rich in arthropods living between the tide lines. More than 7,500 specimens in 94 species and averaging approximately 15 species per collecting station were obtained in 1958. The material contained 91 species of crustaceans (5 barnacles, 3 mysids, 8 cumaceans, 16 isopods, 51 amphipods, and 8 decapods), one thysanuran insect, one pycnogonid, and one pseudoscorpion. Although many of these had previously been recorded from other Canadian Atlantic localities (*see* Bousfield 1952, 1954, 1956a, 1956b, 1958a, 1958b, etc.), a number of interesting new records are presented here. Among these are included one species new to science (*Haustorius spinosus* Bousfield, 1962) and six species new to Canada (*Ligia oceanica* L., *Philoscia muscorum* Scopoli, *Littorophiloscia vittata* Say, *Corophium lacustre* Vanhoffen, *Plesionika* sp., and *Chthonius tetrachelatus* Preyssler). Several species such as *Mancocuma stellifera* Zimmer, *Leptochelia rapax* Harger, *Amphiporeia virginiana* Shoemaker, *Talorchestia megalophthalma* Bate, *T. longicornis* Say, *Corophium insidiosum* Crawford, and *Petrobius maritimus* L. are new to the Bay of Fundy region, and a number of subtidal species such as *Diastylis quadrispinosus* Sars, *Anonyx nugax* Phipps, *Bathyporeia quoddyensis* Shoemaker, *Pontoporeia femorata* Kroyer, *Maera danae* Stimpson, *Casco bigelowi* Blake, and *Corophium crassicorne* Bruzelius were taken in the lowest part of the tidal zone (infralittoral zone of Stephenson, *et al.*, 1954).

ACKNOWLEDGMENTS

I am much indebted to the following specialists for assistance in determining selected arthropod material: Dr. N. S. Jones, Marine Station, Millport, Scotland (Cumacea); Dr. Alceu Lemos de Castro, Museu Nacional, Brazil (Oniscoidea); Dr. Fenner A. Chace, U.S. National Museum (Decapod Crustacea); and Dr. C. C. Hoff, University of New Mexico (Chelonethida). My wife, Barbara, greatly contributed to the success of the field collecting.

PHYSICAL AND HYDROGRAPHICAL FEATURES OF THE REGION

The Bay of Fundy is a narrow, funnel-shaped arm of the Gulf of Maine that separates the western part of the Acadian peninsula from the New Brunswick mainland. From its mouth at Grand Manan Island and Brier Island, the Bay narrows gradually from a width of 40 miles to about 25 miles at the entrance to Chignecto Bay and Minas Channel, twin headwater arms. Over this distance (100 miles), the maximum depth decreases from about 116 fathoms to about 25 fathoms.

The principal hydrographical features of the Bay have been described by several authors and summarized by Ketchum and Keen (1953). Owing to the Coriolis Force, a general counterclockwise drift circulation is imposed on the tidal oscillation. Several medium to large rivers, such as the Petitcodiac, St. John, and St. Croix, enter along the north shore, and the combined effluent, entraining large amounts of salt water as it moves seaward past Grand Manan Island, creates an enormous counter flow of highly saline water inward along the bottom and at all depths along the south side of the Bay. The mean range of tide increases from about 14 feet at Brier Island to nearly 40 feet in Minas Basin and is somewhat greater at corresponding points along the south than along the north side. This extreme tidal action results in vigorous vertical mixing of fresh river water to depths of more than 300 feet and virtually eliminates temperature and salinity stratification in the upper layers. The mixing also results in relatively uniform surface temperatures throughout the year, especially in the outer part of the Bay. These range from an average winter minimum of 2° to 5°C to an average summer maximum of 11° to 13°C (Fuglister, 1947). Temperature extremes are greater in the relatively shallow headwater arms where solar heating is more effective in summer, but where frost action and ice formation in winter may be locally severe (Figures 3A, 4A).

Several types of estuaries are to be found in the Fundy region. These may be classified as warm-water or cold-water types, depending on the temperature of surface waters in summer which, in turn, is critical to reproduction and survival of the fauna. Warm-water estuaries are usually of the coastal plain type (where the river valley has been drowned for a considerable distance above the sea mouth). The water becomes temperature- and salt-stratified during the summer, and a two-layered drift circulation, seawards at the surface and landwards along the bottom, is superimposed on the normal tidal oscillation. The relatively steep shores of the Bay of Fundy do not lend themselves to the formation of coastal plain estuaries, and the tremendous tidal rise and fall tends to keep the waters cold and salt at all depths. Most of the estuaries are short and small and have no two-layered drift circulation and no mechanism for retention of planktonic organisms. The water is cold not only because the drainage basins are short and precipitous and the freshwater is unheated, but because the much larger volume of salt Fundy water mixing with the fresh is cold.

Among the few warm-water estuaries existing in the region is the St. John estuary in south-central New Brunswick. Owing to unusual physical formation of the bed-rock, the mouth of this large inland estuary is partially obstructed. The mid-tide sill so formed prevents influx of salt water except during the upper 10 to 12 feet of the tidal flood. The damping of the tidal wave at the mouth is similar to that of the Bras d'Or Lakes in Cape Breton Island and results in marked thermal and salinity stratification inside the estuary in summer (*see* Hache, 1935; Rogers, 1940). On a much smaller scale, a similar phenomenon has created the warm-estuarine conditions of Tidal Cove at the head of the otherwise cold-salt estuary of Passamaquoddy Bay. On the other hand, the constriction of Digby Gut at the mouth of Annapolis Basin does not form a mid-tide sill and does not appreciably dampen the tidal wave, and the resulting mixing keeps summer temperatures inside the estuary relatively low.

As noted elsewhere (Bousfield and Leim, 1960), the headwaters of Minas Basin become warm and brackish in summer, despite extreme tidal mixing, because of intense solar heating of the tidal flats, efficient absorption of solar heat by turbid waters, and dynamically static circulation that restricts exchange with Fundy waters and permits significant accumulation of fresh river water within the Basin. A similar situation prevails toward the head of Chignecto Bay and Cumberland Basin, although a seaward movement of warm brackish water along the north shore is strongly suggested (Figures 3A, 4A). Also at the head of St. Mary Bay in western Nova Scotia, the extensive shallows and reduced tidal amplitude result in relatively high surface temperatures in summer.

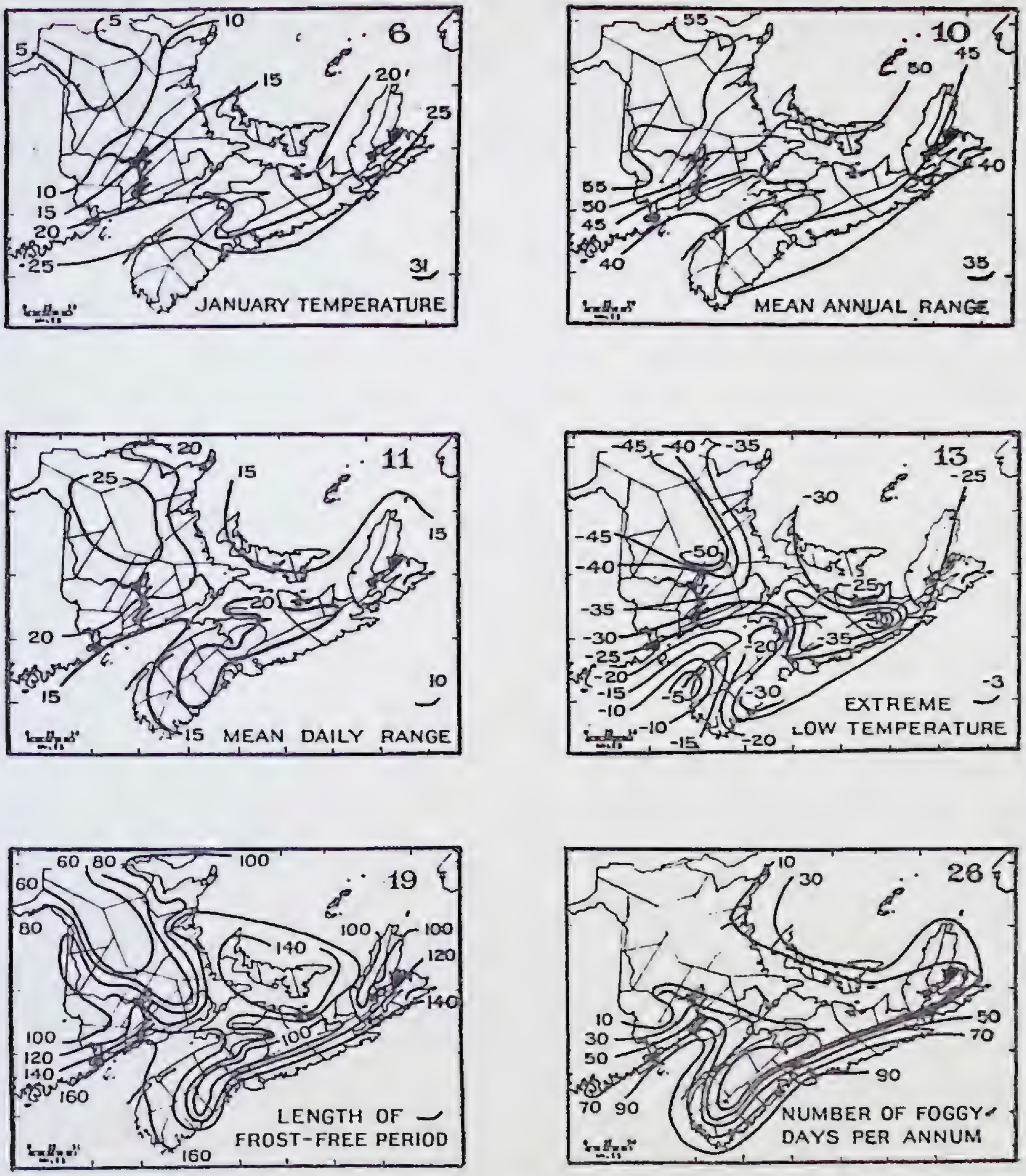

FIGURE 2. Climatological features of the Bay of Fundy Region (after Putnam, 1940).

CLIMATOLOGICAL FEATURES OF THE FUNDY REGION

Intertidal animals are limited by factors of the air environment as well as by those of the sea. Putnam (1940) has described climatological features of the Fundy region, the most pertinent of which are reproduced in Figure 2. The climate of adjacent areas such as the Gulf of St. Lawrence is typically continental, with prolonged cold winters and warm summers; that of Fundy shores is considerably modified, however, by the large water mass of the northern Gulf of Maine where relatively uniform year-round temperatures prevail. In general, the climate is more oceanic toward the mouth of the Bay of Fundy especially along the Acadian coast where, in winter, the cold northwesterly winds are considerably heated as they cross the water and the prevailing warm southwesterly winds of summer are appreciably cooled. Thus shore air temperatures show a mean annual range of only 40° to 45°F, from a low of 20° to 25°F in January to a high of 62° to 64°F in July. Extreme winter lows, critical to survival of shore species during hibernation, rarely fall below —5°F in the St. Mary Bay region, and seldom below —25°F in the entire Fundy region. By contrast, these extreme winter temperatures are much lower in the Gulf of St. Lawrence and coastal Nova Scotia. Along Fundy shores, extreme summer highs rarely attain 90°F, in contrast to prolonged daily highs of 95° to 100°F of other coastal regions and of the interior mainland. Thermal stability in the Fundy region is also indicated by the mean daily range of only 15°F and a prolonged frost-free period of 140 to 160 days. Coastal fog is very heavy, and occurs on 50 to 90 days of every year, mostly during the summer months. Figure 2 indicates that only on Sable Island, on the southeastern tip of Cape Breton Island, and on the south coast of Newfoundland are somewhat similar coastal marine conditions encountered.

TABLE 1.—*Stations visited, Bay of Fundy Region, 1958*

B–New Brunswick Series W–Western Nova Scotia Series
C–Chignecto Bay Series S–Nova Scotia Series
(For data on Stations S14–S16, C15–C18, and M1–M19, *see* Bousfield and Leim, 1960, Table I)

Sta. No.	Date	Locality	Habitat	Tidal level	Water T.°C.	Sal'y ‰
		NOVA SCOTIA				
	July	*Yarmouth Co.—*				
W1	13	Port Maitland	Sand, gravel beach, north side of fishing wharf	HW	—	—
		Digby Co.—				
W2	13	Salmon R.	Steep gravel beach at lighthouse	HW	—	—
W3	13	Cape St. Mary	Flat sand beach, slate bed-rock	LW–HW	12.5	32.3
W4	10	Pond Cove, Brier I.	Sand, gravel, and bed-rock	LW–HW	12.2	32.9
W5	12	Ticken Cove, Church Pt.	Sand and gravel beach	HW	—	—
W6	12	Grosses Cocques	Gravel beach at breakwater	HW	—	—
W7	12	Upper Belliveau Cove	Sand beach east of wharf	HW	—	—
W8	12	New Edinburgh	Gravel bar and sand flat	MW–HW	—	—

TABLE I. *Stations visited, Bay of Fundy Region. 1958*—Cont.

Sta. No.	Date	Locality	Habitat	Tidal level	Water T.°C.	Sal'y. ‰
W9	July 12	Weymouth North	Sand spit at creek mouth	HW	—	—
W10	9	Gilbert Pt.	Salt marsh and pond	MW–HW	> 18°	b.w.
W11	9	Gilbert Cove	Sand and gravel, beach east of wharf	HW	—	—
W12	9	Specht Cove	Sandy mud, shingle, and stone	HW	—	—
W13	9	Brighton	Gravel and sand beach at wharf, muddy sand and boulders	HW	—	—
W14	11	Van Tussel R. near mouth	Mud, sand, pebbles	LW–MW	22.5	b.w.
W15	11	Haight Brook, near mouth	Salt marsh and muddy sand flats	LW–MW	20	b.w.
W16	8	Mink Cove	Steep pebble beach	HW	—	—
W17	8	Little River Cove	Salt marsh at stream mouth	HW	—	—
W18	10	East Ferry, Digby Neck	Steep rocky cliff	HW	9.3	—
W19	8	Sandy Cove, Digby Neck	Sand and boulders, bed-rock	LW–HW	10.0	32.7
W20	11	Gulliver's Cove	Rock, boulder, and pebble beach	MW–HW	—	—
W21	11	Culloden Cove	Gravel, boulders at old wharf	HW	—	—
W22	11	Deep Cove	Flat shale, gravel pools	HW	—	—
W23	11	Prim Pt.	Steep bed-rock, pools	HW	—	—
		Annapolis Co.—				
S1	4	Baudreau Brook	Rock and boulders	HW	—	—
S2	4	Victoria Beach	Gravel spit, south of wharf	HW	—	—
S3	4	Port Wade	Old wharf	HW	—	—
S4	4	Schefner Pt.	Boulders and mud	MW–HW	—	—
S5	4	Annapolis estuary at Granville Ferry bridge	Mud, *Spartina* flats	LW	15	—
S6	5	Delap Cove	Boulders, gravel, bed-rock at stream mouth	HW	10.5	30
S7	5	Coghill L., Bridgetown Reservoir	Stones, mud, aquatic vegetation	—	20	fw.
S8	4	Hampton at stream mouth	Pebbly gravel beach	HW	—	—

TABLE I. *Stations visited, Bay of Fundy Region. 1958*—Cont.

Sta. No.	Date	Locality	Habitat	Tidal level	Water T.°C.	Sal'y. ‰
S9	July 4	Port Lorne	Gravel and sand beach at wharf	HW drif	—	—
S10	4	Port George	Rock and stones, at brook mouth	LW	10.5	32
S11	3	Margaretsville	Small sand beach at wharf	HW	—	—
S11	3	Margaretsville	Boulders, coarse sand, fucoids	LW	11.1	—
		Kings Co.—				
S12	3	Morden Wharf	Gravel beach	HW	—	—
S13	3	Harbourville	Gravel and boulder beach	HW	12.2	—
		NEW BRUNSWICK				
		Albert Co.—				
C1	27	Pt. Wolfe	Gravel flats, boulders, stream mouth	LW	14.8	var.
C2	24	Alma	Sand beach at jetty	LW	18.0	31.4
C3	26	Salisbury B.	Sand and gravel beach	HW	—	—
C4	26	New Horton Beach	Sand beach and salt marsh	LW–HW	—	—
C5	28	Flowerpot Rocks, Hopewell Cape	Sandstone and mud	HW	—	—
		Westmorland Co.—				
C6	28	Johnson's Mills	Mud flats	HW	—	—
C7	28	Peck's Cove	Rocks at bridge	MW–HW	—	—
		NOVA SCOTIA				
		Cumberland Co.—				
C8	30	Upper Minudie	Coarse sand, peat, mud	HW	—	—
C9	30	Lower Cove	Sandstone, mud, sand	LW	16.5	29.9
C10	31	Sand R.	Coarse sand and gravel, boulders, sandstone	LW	13.8	29.8
C11	31	Eatonville R.	Rock, boulders, gravel	LW	12.4	31.3
		NEW BRUNSWICK				
		Charlotte Co.—				
B1	Aug 21	Herring Cove, Campobello I.	Black sand, gravel, rock	LW–HW	10.9	—
B2	21	Mill Cove, Campobello I.	Fine sand, gravel	LW	11.3	31.8
B3	20	Hibernia Cove, Deer I.	Gravel, boulders	HW	—	—

TABLE I. *Stations visited, Bay of Fundy Region. 1958*—Concluded

Sta. No.	Date	Locality	Habitat	Tidal level	Water T. °C.	Sal'y °/oo
B4	Aug. 20	Cummings Cove, Deer I.	Muddy sand, fine gravel	LW	12.7	31.4
B5	20	Fairhaven North, Deer I.	Fine gravel beach	HW	—	—
B6	19	St. Andrews	Stones, bed-rock, muddy sand	LW	11.8	31.2
B7	18	Sand Pt. above Docket I.	Sand and gravel bank	HW	—	—
B8	18	Tidal Cove, Birch Cove	Salt pond, eelgrass	HW	—	—
B9	18	Bocabec R. at hwy.	Stones	HW	—	—
B10	18	Letite Ferry	Conglomerate rock, mud	LW	11.5	31.8
B11	17	Black's Harbour, nr. Pea Pt. light.	Conglomerate rock	LW	12.0	31.6
B12	17	Beaver Harbour	Gravel beach	HW	—	—
B13	17	New R.	Fine sand, boulders, rock	LW–HW	11.7	31.7
B14	16	Mace's B.	Boulders, bed-rock, eelgrass	LW	11.9	31.8
		St. John Co.—				
B15	16	Musquash Hd.	Fine black sand	HW–LW	—	—
B16	16	Spillane Cove near Lorneville	Steep pebble beach	HW	—	—
B17	16	Gondola Pt., Kennebacasis B.	Coarse sand and gravel	HW	18	3.5
B18	16	Mispec Beach	Dark sand, rock, boulders	LW–HW	11.2	31.0
B19	15	Black R. (West B.)	Rock, stones, silt	LW	12.2	31.4
B20	14	West Quaco nr. Quaco Hd.	Coarse sand, mud	LW	14.4	30.7
B21	15	Salmon R.	Boulders and gravel	LW	13.7	30.4

TABLE 2. *Stations visited, St. John Estuary, 1950*
J.–St. John Series

Sta. No.	Date	Locality ·	Habitat	Tidal level	Water T.°C.	Sal'y. °/oo
J5	Sept. 14	Public Landing	Stones, rocky shore	1/4 R.	16.2	5.6
J7	15	Brandy Pt.	Rocks, mud	LW	—	—
J8	15	Belmont	Bed-rock, mud, eel-grass	3/4 R.	15.9	9.9
J13	17	Reversing Falls, w. bank at bridge	Stones, mud	LW	—	—
J14	16	West St. Jonh, ft. of City Line Rd.	Stones, mud	LW	14.5	—
J16	17	West St. John, Navy I. Spit	Stones, mud	LW	—	—
J20	19	Kennebacasis B. at Ryan	Stones, mud	LW	14.9	brackish

FAUNAL LIST

Littoral marine animals of the Fundy region are moderately well known. Early studies of Stimpson, Verrill, Smith, Ganong, and other nineteenth-century biologists, working particularly in the Grand Manan region, have been summarized by Whiteaves (1901). Since that time, marine faunistic surveys have been carried out by the Biological Station at St. Andrews, N.B., and the results have been embodied in numerous publications. Notable publications on marine arthropods are those of Wallace (1919), Rathbun (1929), Needler (1943), and Shoemaker (1947–1949). Johansen (1930) gives a few records of Fundy intertidal species, Stephenson *et al.* (1954) describe intertidal zonation at Hall's Harbour on the south shore of the Bay, and the author's early field work here in 1950 and 1956 has provided material for subsequent publications (Bousfield, 1952, 1954, 1956b, 1958, etc.). Crustacean records from northern New England given by Holmes (1904), Richardson (1905), and Calman (1912) have been amplified more recently by Blake (1929), and Proctor (1933) in the Mt. Desert Island region of Maine, and by others.

A synopsis of the arthropod species is divided into two sections: (1) an annotated list of more or less noteworthy records, and (2) a summary of records of species that occur generally or commonly throughout the region and are well known in the literature.

ARTHROPODA: CRUSTACEA

I. Cirripedia

Balanus improvisus Darwin. Collected at stations B6 and C9 and several stations in the St. John estuary. Although previously known from Tidal Cove and the St. John estuary (Bousfield, 1954), this constitutes the first record of the species from Chignecto Bay.

Lepas anatifera L. Collected on drift logs washed ashore at W4 (Brier Island). This species, and *Lepas hilli* Leach are frequently taken on buoys and shore line debris in western Nova Scotia and mouth of the Bay of Fundy (Bousfield, 1954).

II. Mysidacea

Mysis stenolepis Smith. Collected at B1, B2, B4, B6, B8, and B14, all in the Passamaquoddy Bay area; rather scarce elsewhere in the Fundy region (Bousfield and Leim, 1960).

Mysis gaspensis Tattersall. Seventy immature specimens were taken in a shallow lagoon at B2, constituting the second record of this species in the Fundy region (*see* Tattersall, 1954).

III. Cumacea

Diastylis quadrispinosa Sars. Collected at B4, B13, and B20. A subtidal species.

Diastylis sculpta Sars. Collected at B2, B4, and B13, also a subtidal species.

Eudorella pusilla Sars. One male, collected at B6. *Eudorella difficilis* Blake (1929) may be this species which was described from a female only (Jones, pers. comm.).

Leptocuma minor Calman. Taken at B2 and B13, in fine organic sand.

Mancocuma stellifera Zimmer. Four females collected at B13, extreme LW level. Previously known only from the type locality (Matamek R., Quebec).

IV. ISOPODA

Leptochelia rapax Harger. Eight specimens collected at B8 (Tidal Cove) constitute the first record for the Fundy region, although previously recorded from western Nova Scotia (Bousfield, 1958b).

Limnoria lignorum Rathke. One specimen collected freely at LW level at B2. Common in the Fundy region (M'Gonigle, 1925) but not often remote from woody substratum.

Cylisticus convexus DeGeer. Collected under drift debris at W6 and W10. Sporadically occurring in the Maritime Provinces and restricted by severe winter conditions.

Oniscus asellus L. Collected under beach drift at W6. A somewhat hardier species but not especially common except in coastal localities of Newfoundland (Palmen, 1951).

Philoscia muscorum Scopoli. Fifteen specimens collected under beach drift at W6 constitute the first Canadian record. Previously recorded from Maine (Proctor, 1933).

Littorophiloscia vittata Say. Six specimens taken under damp *Fucus* wrack and pebbles at W19 constitute the first Canadian record. Elsewhere common from Massachusetts southward.

Ligia oceanica L. Six specimens collected in damp *Fucus* drift, HW level of rocky shore at W19. Not previously recorded north of Cape Neddick and Kittery, Maine (Swan, 1956).

Phryxus abdominalis Kr. Two males and one female were parasitic on *Eualus pusiola* at B19. Seldom recorded from intertidal hosts.

V. AMPHIPODA

Anonyx nugax Phipps. Collected at extreme LW level, B6 and B14.

Orchomenella minuta Kr. Collected in sand at LW level, B6 and B14.

Pontoporeia femorata Kr. Two specimens from the infralittoral zone at B6 appear to be the first intertidal records of this species.

Amphiporeia virginiana Shoemaker. Ten specimens collected on the surf-pounded sand flats at Cape St. Mary (W3) constitute the first record for the Fundy region, although common from Halifax to Yarmouth (Bousfield, 1958b).

Bathyporeia quoddyensis Shoemaker. Collected at LW level of sand beaches at B13, B18, and C9. Known only from the Bay of Fundy region where it is widely distributed (Shoemaker, 1949).

Haustorius spinosus Bousfield. Known only from stations of the present survey (Bousfield, 1962, in press).

Ampelisca spinipes Boeck. One specimen, doubtfully referable to this European species, collected at LW level at B6.

Haploops tubicola Lillj. Five specimens, LW level C10. A subtidal species.

Monoculodes edwardsi Holmes. One specimen. LW level, B13, in sand.

Monoculodes tesselatus Schneider. Extreme LW level, B6 and B11.

Neopleustes sp. Extreme LW level at B2 and B4, on sand.

Metopa groenlandica Hansen. Single specimens, LW level B2, C10.

Gammarus setosus Dement. Only 85 specimens at 9 localities (W4, W22, S6, S10, B18, C1, C2, C10, and J16) illustrate the scarcity of this brackish-water subarctic gammarid near the southern limit of its range.

Melita dentata Kr. Eight specimens, LW level, B6. This and the following two species are subtidal forms.

Maera danae Stimpson. Sixteen specimens, LW level, B6.

Casco bigelowi Blake. Seven specimens, LW level, B6.

Orchestia gammarella Pallas. Collected under beach drift, especially on gravel beaches, at B8, B16, and W10, and observed at several localities in western Nova Scotia. Replaced by *O. platensis* towards the head of the Bay and by *O. grillus* in salt marshes.

Talorchestia megalophthalma Bate. Common on the exposed flat sand beach at Cape St. Mary (W3), but inner sand beaches are populated by *T. longicornis*. Neither species previously recorded from the Bay proper (Bousfield, 1958a).

Photis macrocoxa Shoem. Four specimens, LW level, B4. A subtidal species.

Ischyrocerus sp. One immature male specimen of the *megacheir* group, LW level, B18. Almost certainly a subtidal species.

Jassa falcata Montagu. LW level at W3; also on buoys at W2 and W4 in 1950. Not common along shore within the Bay proper.

Leptocheirus pinguis Stimpson. An essentially estuarine species of muddy bottoms, LW level, B4 and B6.

Corophium crassicorne Bruzelius. A single specimen, extreme LW level, B2. A subtidal species, Gulf of St. Lawrence to Long Island Sound.

Corophium volutator Pallas. A warm-water intertidal species extending nearly into fresh water; common only at C4, C9, and C10 in Minas Basin and elsewhere at the head of the Bay.

Corophium insidiosum Crawford. Collected only in warm-water estuaries, B8 and W19; likely occurs in the St. John estuary also. Though one of the most common amphipod species in the shallows of southwestern Gulf of St. Lawrence and occurring at selected localities along the outer coast of Nova Scotia, this species has not previously been reported from the Bay of Fundy.

Corophium lacustre Vanhoffen. Two specimens from the St. John estuary at J8 constitute the first Canadian record of this species. Previously unknown north of the Hudson River.

VI. DECAPODA

Plesionika sp. One immature specimen collected among fucoids at extreme LW level at S11 is probably referable to either *P. tenuipes* Smith or *P. acanthonotus* Smith recorded from New England waters by Wigley (1960).

Eualus pusiola Kr. Among algae on boulders, LW level, B14 and B19. Normally subtidal.

ARTHROPODA: INSECTA

I. THYSANURA

Petrobius maritimus L. On rocks in spray zone at HW level, W4, W15, W22, all in western Nova Scotia. Previously recorded in Canada from

Cape Fourchu, near Yarmouth (Bousfield, 1958b) and along the New England coast northward to Cape Neddick, Maine (Swan, 1956).

ARTHROPODA: ARACHNIDA

I. PANTOPODA

Phoxochilidium femoratum Rathke. LW level, B18 and W4, on sand. This species and *Pycnogonum littorale* Strom are common intertidal species known in the region (Needler, 1943).

II. CHELONETHIDA

Chthonius tetrachelatus Preyssler. Three male specimens of this intertidal pseudoscorpion collected under beach debris at HW level at W6 constitute the first Canadian record of the species.

The following species were taken or observed commonly in suitable habitats or cast ashore in beach drift throughout the Fundy region:

CIRRIPEDIA:

Balanus balanoides L., *B. crenatus* Brug., *B. balanus* L.

MYSIDACEA:

Neomysis americana Smith

CUMACEA:

Oxyurostylis smithi Calman, *Diastylis polita* Smith, *Lamprops quadriplicata* Smith

ISOPODA:

Cirolana polita Stimps., *Chiridotea caeca* Say, *Chiridotea tuftsi* Stimps., *Idothea baltica* Pallas, *I. phosphorea* Harger, *Edothea montosa* Stimpson, *Jaera marina* L., *Porcellio scaber* Latr.

AMPHIPODA:

Tmetonyx nobilis Stimps., *Amphiporeia lawrenciana* Shoem., *Phoxocephalus holbolli* Kr., *Sympleustes glaber* Boeck, *Calliopius laeviusculus* Kr., *Pontogeneia inermis* Kr., *Dexamine thea* Boeck, *Gammarellus angulosus* Rathke, *Gammarus oceanicus* Segerstr., *G. lawrencianus* Bousfield, *G. tigrinus* Sexton, *G. mucronatus* Say, *G. duebeni* Lillj., *Marinogammarus finmarchicus* Dahl, *M. obtusatus* Dahl, *M. stoerensis* Reid, *Hyale nilssoni* Rathke, *Orchestia platensis* Kr., *O. grillus* Bosc., *Talorchestia longicornis* Say, *Amphithoe rubricata* Mont., *Ischyrocerus anguipes* Kr., *Unciola irroratus* Say, *Corophium bonelli* M.-E., *Caprella septentrionalis* L.

DECAPODA:

Crago septemspinosus Say, *Homarus americanus* M.-E., *Pagurus acadianus* Benedict, *Cancer irroratus* Say, *C. borealis* Jonah, *Carcinides maenas* L.

TABLE 3. *Regional abundance of intertidal arthropods in the Bay of Fundy*

Region	Passamaquoddy Bay	Lower Fundy	Upper Fundy	Chignecto N. side	Chignecto S. side	Minas Channel* N. side
LW coll. stations	B2, B4, B6	B10, B11, B14, B15	B18, B19, B20, B21	C1, C2, C4	C11, C10 C9	C17, C15
Av. no. specimens per sta.	26	20	17	10	16	26
% of total Fundy species	60	51	40	21	32	42
Region	Western N.S.	Central N.S.	Minas Ch. S. side	Minas Basin* S. side	Minas Basin* N. side	Minas Basin* Upper
LW coll. stations	W3, W4, W15, W19	S6, S10, S11	S14, S15, S17	M2, M8, M10	M15, M17, M19	M11, M12, M13
Av. no. specimens per sta.	20	17	12	19	18	12
% of total Fundy species	50	32	19	32	35	24

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* Data from Bousfield and Leim, 1960.

ECOLOGICAL AND ZOOGEOGRAPHICAL AFFINITIES OF THE FAUNA

The Bay of Fundy region is relatively rich in intertidal arthropods, both as to numbers of species and of individuals. The average number of species per station was 15, whereas using essentially similar collecting methods and similar ecological coverage in the 30 to 40 stations visited, this figure was only 13 in southwestern Nova Scotia in 1956, 11 in Cape Breton Island and Newfoundland in 1954, and only 10 in the St. Lawrence estuary and Gaspé coast in 1953. Preliminary estimates of material taken in the southwestern Gulf of St. Lawrence in 1960 place this figure at about 11 species per station. It is evident that more arthropod species are able to colonize the tidal zone in the Fundy region because of less rigorous extremes of temperature, salinity, and humidity there. The nutrient-rich waters in certain parts of the Bay support large populations of intertidal animals, and lack of ice abrasion and of extreme frost action enables these large populations to persist throughout the winter.

The richness of the intertidal arthropod fauna varies from area to area. Huntsman (1952) found that planktonic marine life, notably young herring and their food organisms, was concentrated by the circulation mainly near the mouth and in the outer part of Passamaquoddy Bay. Zooplankton from the rich Gulf of Maine region is drawn into the Bay mainly along the north shore of Nova Scotia but decreases in amount going inward and becomes poor through lack of phytoplankton, which is unable to grow in the deep, turbid, and turbulent headwater arms of Minas Channel and Chignecto Bay. However, animals that feed on detritus and organic debris on the bottom are the dominant feeding types here (Bousfield and Leim, 1960).

Table 3 gives data on the abundance of intertidal arthropods at LW stations of the present study region. On the north side of the Bay the number of species per station decreases gradually but significantly from a high of 26 in the Passamaquoddy Bay area to 10 along the north side of Chignecto Bay; the regional percentage of total species taken during the survey decreases correspondingly from 60 per cent to 21 per cent. On the south side of the Bay, a similar landward decrease may be noted, with corresponding numbers less in each case, from western Nova Scotia (Digby Neck) to the south side of Minas Channel. The unusually rich fauna along the north side of Minas Channel is partly attributable to the more diverse habitats (e.g., wave-protected sandy bottoms at C15) and to sampling only two relatively rich stations in the area; the composition of the fauna does reflect the large number of detritus feeders here. Minas Basin shows a somewhat richer fauna than does the upper Bay of Fundy. Huntsman (1952) found this to be the case with planktonic microcrustacea and fish, and attributed it to an endemic population of phytoplankton within the Basin. However, the benthic fauna of the muddy estuarial upper Basin is relatively poor and not much richer than that of the north side of Chignecto Bay where similar conditions prevail. The south side of Chignecto Bay is considerably richer than the north side because it is influenced by high salinity and organically rich ocean water drawn landwards along that shore by the counter-clockwise circulation.

The suitability of the intertidal climate and of hydrographical factors, and the diversity of substrata for intertidal life along Fundy shores are illustrated by the regional distribution of selected arthropod species (Figures 3, 4). The distribution of *Gammarellus angulosus* (Figure 3B) coincides with wave-exposed kelp and fucoid rocky shorelines where summer temperatures are less than 13°C and salinities greater than 31‰. With slightly greater latitude this distribution is characterictic of most cold-temperate, obligate-intertidal, and shallow-water species in the region, viz., *Amphithoe rubricata, Ischyrocerus anguipes, Dexamine thea, Sympleustes glaber,* and *Pontogeneia inermis.* With slightly greater range it also typifies the distribution of the tide-pool aquatic species as *Marinogammarus* spp., *Hyale nilssoni,* and *Carcinides maenas,* although these are tolerant of considerably lower salinities and range considerably farther into certain estuaries. The Fundy littoral fauna is predominantly boreal (60 of 96 species) and resembles the fauna of outer Nova Scotia and southern Newfoundland in this respect.

Except for the common beach fleas and sandhoppers (*see* Bousfield, 1958a), most of the HW drift-line terrestrial and semi-terrestrial arthropods occur almost exclusively along the shores of western Nova Scotia, from Yarmouth to Annapolis Basin. This is particularly true of oniscoidean isopods such as *Ligia oceanica, Philoscia muscorum, Littorophiloscia vittata,* and others, the thysanuran *Petrobius maritimus,* and the pseudoscorpian *Chthonius tetrachelatus* that are known in Canada only from this region. Palmen (1951) stresses the suitability of conditions of winter hibernation in southern and southeastern Newfoundland with its high degree of precipitation and ice-free coastal waters to account for the distribution of *Oniscus asellus* in that region. Similarly we may account for the concentration of *Oniscus* and its bed-fellows in the western Nova Scotia intertidal zone. Climatological data (Figure 2) show that extreme low winter temperatures rarely fall below —10°F, that coldest winter averages are about 25°F, and that the frost-free period is 160 days. These levels are above all other coastal marine areas in the Maritime Provinces except Sable Island, which is truly oceanic in position, and compare with winter conditions in the Cape Cod region of Massachusetts where these species normally exist. Since Putnam's data were obtained from meteorological stations at least a few miles from shore and several feet above sea-level, we might expect winter conditions to be even less severe along the shoreline where these animals are living. Records of *Orchestia gammarella* in the Bay of Fundy and probably in Eastern Canada generally (*see* Bousfield, 1958a) would lie inside the extreme winter low isotherm of —25°F, and would be approximated by the average January isotherm for 20°F, or the isobar for 140 frost-free days. By contrast, these winter thermophiles have not been found in the Gulf of St. Lawrence or along the outer coast of Nova Scotia where winter conditions are more rigorous. Other intertidal thermophiles are likely to be discovered through more intensive investigation of the St. Mary Bay region. This is a region of mild winters and cool moist summers, an area of uniform conditions not only from day to day but also year-round. Thermal stability and lack of extremes permit the survival of many species that are primarily aquatic or poorly fitted for terrestrial existence. Only a few very hardy types can survive the ice-scoured and frozen tidal zones elsewhere in the Canadian Atlantic region.

The distributions of *Talorchestia* spp. and *Amphiporeia virginiana* (Figure 4c) are limited mainly by suitable substratum and physiographical factors of the environment. That of *T. longicornis* almost exactly conforms with the location of fine-sand beaches in the Fundy region; elsewhere there are none. *T. megalophthalma* occurs only on the outermost surf-swept beaches where the slope of the shore is relatively gentle. Neither species of sandhopper had previously been recorded from the Bay of Fundy, but present findings are consistent with the fact that *T. longicornis* is more tolerant of estuarine conditions (Bousfield, 1958a). *Amphiporeia virginiana* is a species of clean, surf-swept, ice-free sand beaches where it tends to concentrate at the mouths of small streams. Also found in this situation, but somewhat more cold-tolerant and eurybathic, are *Tmetonyx nobilis*, *Amphiporeia lawrenciana*, and *Leptocuma minor*.

The distribution of estuarine arthropod species is illustrated by Figure 4B. With respect to faunistic assemblages, the estuaries have been classified as warm-water or cold-water types, depending on surface temperatures in summer which are limiting to the reproduction and survival of the organisms. Only in warm-water estuaries of the coastal plain type (such as Tidal Cove and St. John estuary) or where solar heating in summer is appreciable (Chignecto Bay and Minas Basin) do we find endemic populations of warm-water estuarine organisms such as *Balanus improvisus* having long-lasting planktonic larval stages. Although this cirripede was not taken in St. Mary Bay, the presence there of warm-

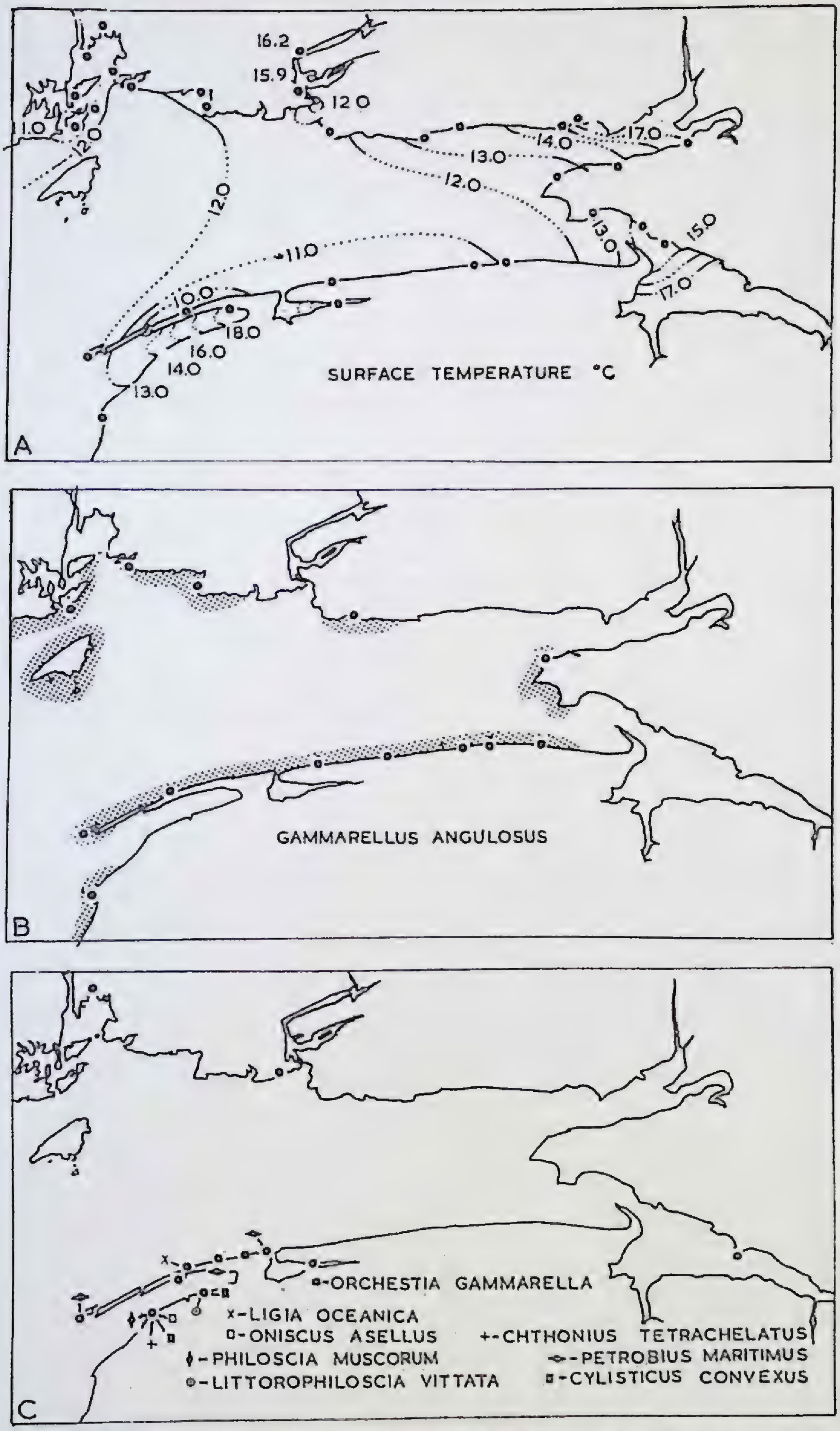

FIGURE 3. Distribution of physical parameters and arthropod species at shore localities in the Bay of Fundy region.
A—Surface temperature.
B—Amphipod crustacean *Gammarellus angulosus*.
C—Winter-limited drift-line arthropods.

water bivalves such as *Volsella demissa*, *Pitar morrhuana*, and *Mercenaria mercenaria* would indicate suitable conditions for this barnacle species. On the other hand, the numerous small, cold-water estuaries of the Fundy region (p. 44) enable subarctic estuarine crustaceans such as *Mysis gaspensis* and *Gammarus setosus* to survive in these special conditions well to the south of their normal ranges. Owing to low summer temperature and brief period of air exposure, a number of subarctic cold-stenothermal species that normally occur subtidally, such as *Anonyx nugax*, *Pontoporeia femorata*, *Melita dentata*, and *Casco bigelowi*, find conditions suitable in the infralittoral zone, particularly in the outer part of the Bay of Fundy.

The amphipod genus *Corophium* illustrates the diversity of intertidal and estuarine conditions in the Fundy region (Figure 4B). The cold-water species *C. bonelli* is widespread on suitable bottom along the outer shores and estuaries. On the other hand, *C. volutator* crawls about on the extensive mud flats of warm tidal headwaters and may inhabit only the winter-mild estuaries throughout its range; *C. insidiosum* is restricted to warm but less turbid 'eelgrass' estuaries; and *C. lacustre* is a warm-water, low-brackish species that finds conditions of salinity optimum in the upper St. John estuary. The tanaid isopod, *Leptochelia rapax*, occurs in similar warm-brackish situations.

The presence of a distinct and varied population of intertidal winter thermophiles, isolated from mainland populations in a relatively small part of western Nova Scotia, raises the interesting question of their origin. Wind dispersal or log-rafting of such small and easily transported animals from populated areas to the south, such as the Cape Cod region, is a tempting and plausible theory. Nova Scotia is directly in the track of many late-summer hurricanes that move up the east coast of the United States and deposit debris, including storm-blown birds, in this region. Also, the frequent appearance of goose barnacles, salps, and subtropical marine fishes in coastal waters and the occurrence of oceanic flotsam on the beaches of this region offer strong support for such a theory. Undoubtedly some immigrants are derived in this way, particularly small terrestrial and fresh-water animals that are known to be widely dispersed in this manner. However, a hypothesis of chance influx alone would scarcely account for the complexity of the established intertidal thermophilic fauna and for the amphi-Atlantic distribution of many of the species. Moreover, it would ignore the probable post-glacial history of the region which actually indicates another, more likely, origin for these northern populations.

The data of Flint (1947) and Livingstone, *et al.* (1958) on the post-glacial history of the Canadian Atlantic Provinces suggest that, immediately following the fourth and final ice advance, sea-levels were perhaps 200 to 300 feet below present levels, and that a cold-temperate biota prevailed at that time (15,000 years ago). The weight of ice had considerably depressed land areas on the northwest side of the hinge line of zero-depression that ran more or less along the present axis of the Acadian or Nova Scotian peninsula. Conversely, by isostatic imbalance and lowered sea-levels, the present offshore shoals, such as the Grand Banks, Sable Island Banks, Brown's Bank, and George's Bank, must have appeared above sea-level as extensive oceanic islands or peninsulas connected to adjacent parts of the mainland. These outer

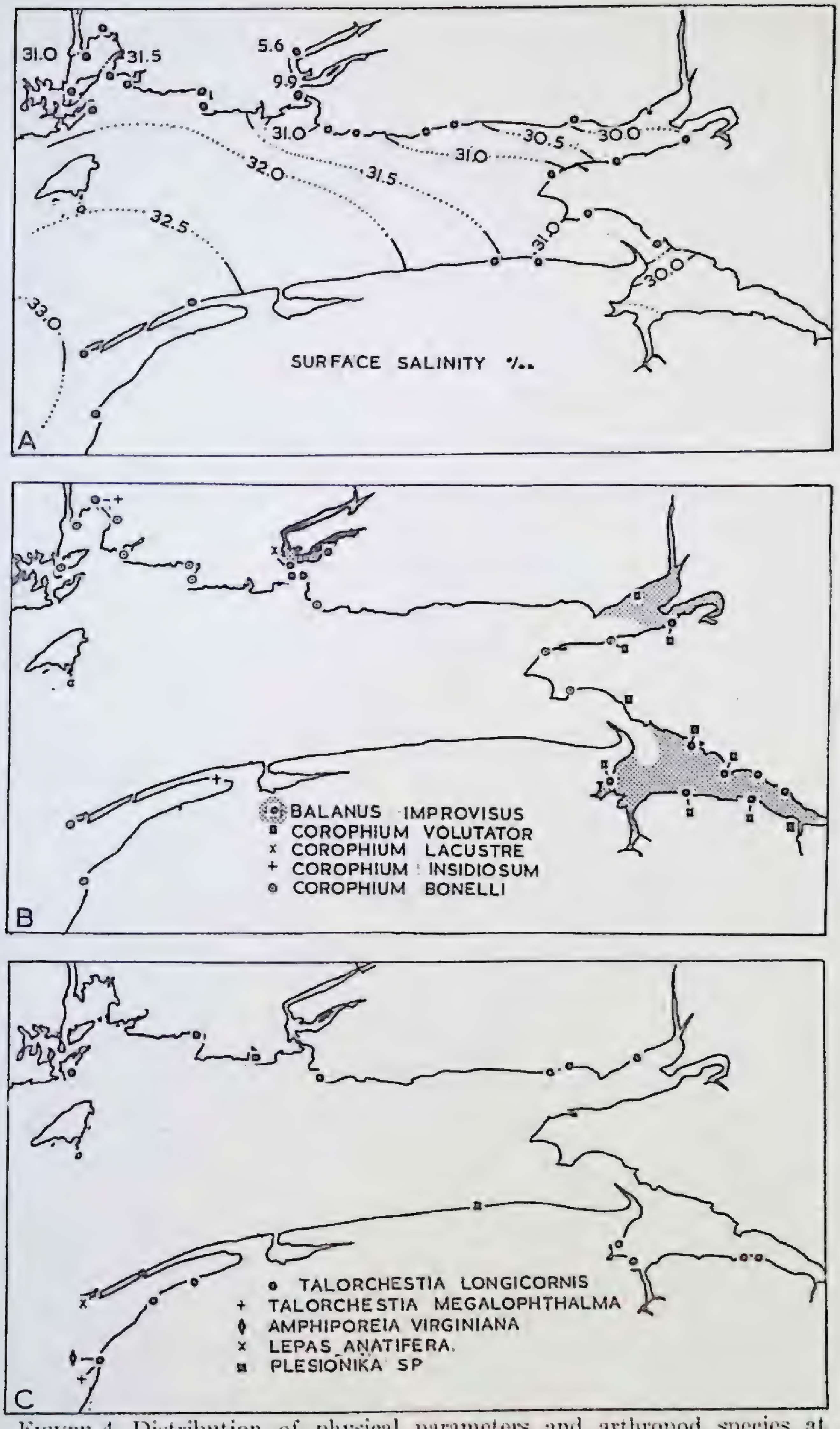

FIGURE 4. Distribution of physical parameters and arthropod species at shore localities in the Bay of Fundy.
A—Surface salinity.
B—Estuarine barnacle (*Balanus improvisus*) and tube-dwelling amphipods (*Corophium* spp.).
C—Sand beach and open ocean crustaceans.

land masses would have been surrounded by relatively shallow water which, because of the close proximity of the Gulf Stream and diversion of the cold Labrador current by the raised Grand Banks, would have been relatively warm. The outer coasts of these islands would thus likely have escaped glaciation and possibly have provided a suitable refugium for many southern intertidal and even terrestrial and freshwater species, as Fassett (1928) and others have postulated for certain relict plants. As the climate became much milder, the glacier retreated rapidly, particularly in coastal regions. The insular populations would then have dispersed inland, possibly reaching their maximum extent during the Climatic Optimum of 6,000 years ago. This inland penetration would probably have been short-lived, however. The widespread occurrence of raised beaches above glacial deposits in the region indicates rapid post-glacial uplift of inland areas, finally freed of the heavy ice load. The shore climate then probably became more continental, with continuing warm summers but colder winters, and the intertidal thermophiles would have retreated again to the outer shores. In final stages of deglaciation, sea-levels rose above and drowned the offshore islands; the intertidal thermophilic populations would then have been obliterated in all but the mildest continental areas, today represented by western Nova Scotia, southeastern Newfoundland, and, of course, Cape Cod to the south. As sea-levels continue to rise, the coastal mainland climate will become more oceanic, and these relict populations in Nova Scotia will probably expand their ranges once again.

This proposed sequence of events may be interpreted to explain the disjunct distributions of warm-estuarine animals along the shores of the Bay of Fundy and the Gulf of Maine. During the period of minimum sea-levels, the Gulf of Maine was a warm inland sea where, as the Boston marine sediments would indicate (Flint, 1947, p. 492), the inshore shallows and estuaries were populated essentially by a warm-temperate fauna. The recent discovery of subfossil molluscs of Carolinian affinities in the Minas Basin region (Bousfield, 1961) would also lend support to this belief. Fassett (1928) postulated that estuarine vascular plants migrated northward through the warm Bay of Fundy and the then-submerged Chignecto Isthmus to reach their present positions in large warm estuaries of the Gulf of New Brunswick. However, following uplift of the Chignecto Isthmus, probably 6,000 years ago, the Bay with its marine fauna was cut off from the warm Gulf waters to the north. As Maritime land areas reached a new static level, sea-levels continued to rise rapidly because of continued large scale ice-melting in arctic and subarctic regions. The offshore islands became submerged, and the cold Labrador current began to make itself felt along the outer coast of Nova Scotia. The Gulf of Maine became deeper and wider, particularly at the entrance, and colder, not only as the warm Gulf Stream was forced offshore, but as tidal amplitude and vertical mixing increased in the blind funnel of the Bay of Fundy. Thus the warm fauna was gradually obliterated throughout most of the region; only a few relict populations survived in isolated pockets of headwater estuaries. A cold-water fauna spread throughout the Gulf of Maine, particularly in the northern part, where it is now dominant. The process is still continuing as summer temperatures become lower. Populations of oysters, quahogs, and blue crabs have disappeared from estuaries of the outer coast of Nova Scotia within recorded times, and the Ipswich sparrow that breeds only on shrinking Sable Island is perhaps the sole survivor of a post-glacial terrestrial fauna that was undoubtedly widely dispersed over former offshore islands and the Acadian peninsula.

SUMMARY

The Bay of Fundy is characterized by a relatively rich intertidal arthropod fauna. The species are most numerous at the mouth of Passamaquoddy Bay on the north, and St. Mary Bay on the south side. Numbers decrease landwards to Cape Chignecto but increase again in the twin headwater estuaries of Chignecto Bay and Minas Basin because of endemic estuarine faunas. Owing to the year-round stability of surface temperatures in the northern part of the Gulf of Maine and to the variety of intertidal substrata, more arthropod species live intertidally in the Fundy region than elsewhere in Eastern Canada. The favourable marine climate moderates the cold continental winter winds and warm southwesterly summer winds and makes for year-round uniformity of the air environment to which the animals are variously exposed. Several terrestrial drift-line arthropods are known in Canada only from this region because conditions for winter hibernation here are apparently not limiting. The finding of other winter thermophiles, elsewhere known from southern New England and Western Europe would probably result from a more thorough investigation of the St. Mary Bay region. The post-glacial history of the Fundy region would suggest that these animals are relict groups of populations formerly widespread on insular and peninsular land masses that have since been inundated and today form Sable Island and Brown's and George's banks. As the inshore climate becomes more oceanic and winters ameliorate with continued deepening of Fundy waters, these animals will once again expand their ranges. The estuarine fauna of the Fundy region is very diversified, with species that are endemic to both cold- and warm-water estuaries, and reflects the wide variety of estuarine conditions that exist along the shores of this remarkable marine region.

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NEW HAUSTORIID AMPHIPODS FROM THE CANADIAN ATLANTIC REGION

By E. L. Bousfield

The genus *Haustorius* Müller, 1775, comprises a group of amphipod crustaceans that are highly modified for burrowing in the sandy marine substratum. Barnard (1957) more rigorously defined the genus to include only the two North Atlantic species, *H. arenarius* Slabber from Europe and *H. americanus* Pearse from the Gulf of Mexico. At the same time, he created the genus *Eohaustorius* for reception of the three North Pacific species: *E. washingtonianus* Thorsteinson, *E. eous* Gurjanova, and *E. cheliferus* Bulycheva.

As a result of surveys on Canadian Atlantic intertidal invertebrates (Bousfield, 1956; Bousfield and Leim, 1960), interesting finds of material, determined initially as *H. arenarius* Slabber, have been made. However, careful examination and comparison of more extensive material from the Gulf of St. Lawrence and from the Bay of Fundy indicate that these respective populations are—

(1) specifically distinct from one another,
(2) specifically distinct from European material of *H. arenarius*, and
(3) unlike *H. americanus*, or clearly referable to other described American material of this genus.

Accordingly, the Gulf of St. Lawrence species is herewith described as *Haustorius canadensis* n. sp., and the Bay of Fundy species as *Haustorius spinosus* n. sp.

The author is much indebted to Dr. Torben Wolff, Zoological Museum, Copenhagen, Denmark, and to Dr. C. Edwards, Marine Station, Millport, Scotland, for providing comparative material of *H. arenarius* used in this study, and gratefully acknowledges the assistance of Mrs. J. G. Stamper in the preparation of the figures.

Key to North Atlantic Species of Haustorius

1. Peraeopod 2, short, unlike peraeopod 1; lobes of telson arise separately from urosome; maxilla 2, inner and outer plates subequal....*Eohaustorius* (Pacific).
Peraeopods 1 and 2 subequal and alike; telson cleft or entire; maxilla 2, outer plate much larger than inner plate, heavily setose ......*Haustorius* (Atlantic). 2
2. Uropod 3, outer ramus 1-segmented; lobes of telson each with apical fanwise row of long slender spines; uropod 1, rami widest at apex, longer than peduncle .... *H. americanus* Pearse.
Uropod 3, outer ramus 2-segmented; telson lobes armed with clusters of relatively short spines or setae; uropod 1, rami slender, not longer than peduncle 3
3. Abdominal side plate 3, posterior angle produced as a stout spine; antenna 1, accessory flagellum 2-segmented; posterior margin of telson convex, lined throughout with slender spines except at median notch .... *H. spinosus* n. sp.
Abdominal side plate 3, posterior angle smoothly rounded; accessory flagellum 3–5 segmented; posterior margin of telson concave, spines clustered at lateral corners 4

4. Peraeopod 5, posterior margin of segment 4 armed with 3–4 groups of spines; uropod 1, concave posterior margin lined throughout with spines, outer ramus bearing spines only .... *H. arenarius* Slabber.
Peraeopod 5, posterior margin of segment 4 armed with only one group of spines; uropod 1, posterior margin with spines concentrated proximally and distally; outer ramus bearing long setae and spines ...... *H. canadensis* n. sp.

Genus HAUSTORIUS Müller, 1775, emend Barnard, 1957

1. **Haustorius arenarius** Slabber, 1775

(Figs. 1, 2)

syn: *H. arenarius* Sars 1895, p. 136, pl. 46
H. arenarius Stebbing, 1906, p. 124
H. arenarius Chevreux and Fage, 1925, p. 95
non: Lepidactylus dytiscus Say, 1818, p. 380
H. arenarius Paulmier, 1905, p. 157, fig. 25
H. arenarius Holmes, 1904, p. 476

Material Examined

1. Beach, Lökken, NW Jutland, Denmark, June 12, 1919, Th. Mortensen coll.—2 males (1 figured). NMC 2306.
2. Lynas, Isefiord, Seeland, Denmark, Dansk Biol. Sta., May 24, 1913—1 fem. (ovig.). NMC 2308.
3. Kattegatt, Denmark, May 26, 1891—2 females. NMC 2307.
4. Beach at Den Helder, Holland, July 7, 1920, Th. Mortensen—1 imm. NMC 2309.
5. Kames Bay, Isle of Cumbrae, Scotland, beach, LW level, June 20–22, 1961, C. Edwards coll.—21 males, 12 females (mostly ovig.), 4 imm. NMC 2310.

Description

The species has been described and figured by Sars (1895), Stebbing (1906), and more recent European authors. The following description serves to amplify previous work and accentuate diagnostic points of difference between this European species and the American-Atlantic species described on following pages. *Haustorius arenarius* has not authentically been recorded elsewhere and appears to be the sole European representative of a group that is endemic to the American Atlantic region.

Male (11–13 mm) (Figs. 1, 2): Head more or less rectilinear, width 1½ times length; anterior margin concave on either side of short triangular rostrum. Eyes indistinct or unpigmented in adult specimens. Antenna 1, flagellum of 8 segments, distally with calceoli; accessory flagellum 4 to 5 segmented. Antenna 2, posterior lobe of peduncular segment 4 not extending distally beyond junction with segment 5, which is little expanded; flagellum of 10 segments.

Mandible, incisor tricuspate, lacinia bicuspate; spine row with 8 slender blades; terminal segment of palp with up to 15 slender apical spines. Maxilla 1, inner plate with 10 plumose setae; basal lobe moderately large, ciliated. Maxilla 2, outer plate more than twice as long as wide, outer margin lined with rather short fine setae. Maxilliped, inner plate

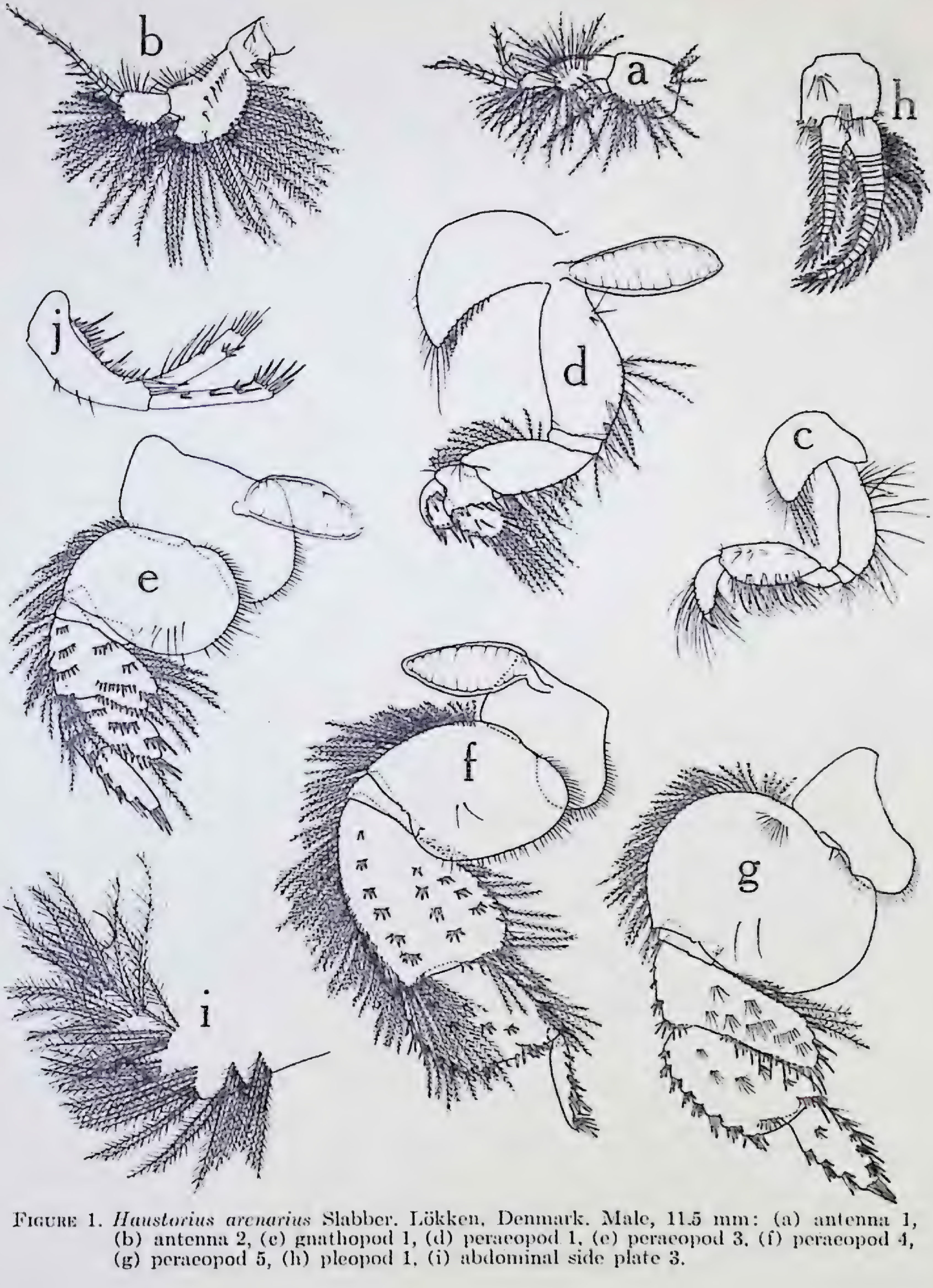

FIGURE 1. *Haustorius arenarius* Slabber. Lökken, Denmark. Male, 11.5 mm: (a) antenna 1, (b) antenna 2, (c) gnathopod 1, (d) peraeopod 1, (e) peraeopod 3, (f) peraeopod 4, (g) peraeopod 5, (h) pleopod 1, (i) abdominal side plate 3.

not unusually narrow, outer plate with smoothly arched outer margin; palp, segment 3 geniculate, horizontal lobe longer than axial stem. Lower lip, inner lobes large, triangular.

Gnathopod 1 simple, segment 2 only slightly concave proximally, segments 5 and 6 not exceptionally powerful. Gnathopod 2, segment 2 slender, linear, dactyl forming a minute terminal chela with segment 6. Peraeopod 1 strongly fossorial, posterior lobe of segment 5 large, hind margin with spines and long plumose setae. Peraeopod 3, outer face of segment 4 with several spines in each spine row; hind lobes of segments 4 and 5 considerably produced posteriorly. Peraeopod 4, length of segment 4 about 1½ times width (lateral), facial spines typically grouped in clusters of 3. Peraeopod 5, segment 4 with rounded posterior angle, posterior border with 3 to 4 spine groups, lower margin lined with long heavy spines.

Abdominal side plate 3, lower margin smoothly rounding, armed with 7 to 8 groups of long plumose setae. Uropod 1, peduncle longer than slender, subequal rami; posterior (upper) margin concave, lined throughout with heavy spines; long setae on inner ramus only. Uropod 2 small, biramous, rather hairy. Uropod 3, outer ramus 2-segmented, distinctly longer than inner ramus. Telson entire, width twice the length; posterior margin concave, shallowly notched, lateral angles each armed with 10 spines.

Remarks

The large species from the Cape Cod region, described by Holmes (1904) as *Haustorius arenarius*, cannot be Slabber's species nor either of the species described herewith as new to science. The shape of the telson (p. 476) is distinctive with rounded lobes, sharp apical cleft, and extra lateral spine groups. The photographic illustration (Plate V, fig. 2), though not clear in critical areas, does show peraeopod 4, posterior margin of segment 2 slightly concave distally and segment 4 long and relatively narrow. Until further material from off Martha's Vineyard can be examined and fully described, the status of Holmes' species is uncertain. Material from New York City described and figured by Paulmier (1904) is clearly different not only from *H. arenarius* but also from Holmes' species. Paulmier's fig. 25 shows (1) antenna 2 with broadly expanded peduncular segment 5 and prominent plumose setae on basal flagellar segments; (2) richly setose posterior margins of segment 2 in both peraeopod 3 and 4; (3) segment 5 of peraeopod 4 broadly expanded anteriorly; (4) segment 4 of peraeopod 5 with only one group of spines on posterior margin; and (5) both rami of uropod 1 lined posteriorly with numerous long setae. The exact status of *Lepidactylus dytiscus* Say, 1818, can also not be determined until further material from the coast of Georgia and Florida is redescribed. Say's description is sufficiently detailed to leave no doubt that he is dealing with a species of *Haustorius* or closely allied genus, but the small size of his species (6 mm), the presence of well-pigmented eyes, the short flagellum and accessory flagellum of antenna 1, and the general behaviour of the animal in the field are unlike the corresponding characters in *H. arenarius*. Similarly, the possibility is remote that Say's species will prove truly synonymous with any of the species treated herewith.

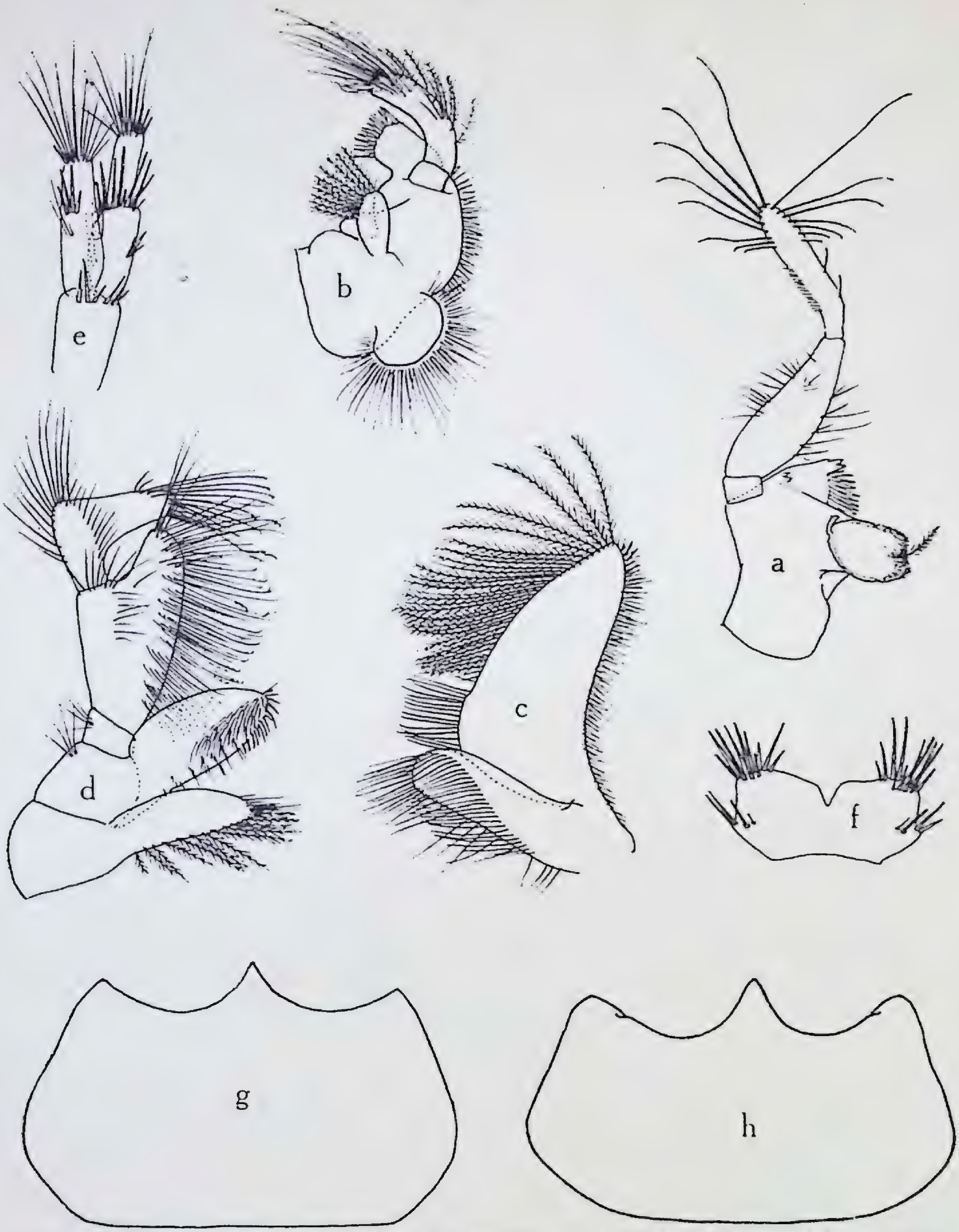

FIGURE 2. *Haustorius arenarius* Slabber. Lökken, Denmark. Male, 11.5 mm: (a) mandible, (b) maxilla 1, (c) maxilla 2, (d) maxilliped, (e) uropod 3, (f) telson.
Haustorius canadensis n. sp., Keppoch Beach, P.E.I. Female TYPE 8.0 mm: (g) head.
Haustorius spinosus n. sp., Sandy Cove, N.S. Female TYPE 12 mm: (h) head.

2. **Haustorius canadensis** n. sp.

(Figs. 3, 4)

syn: *Haustorius arenarius* Bousfield, 1956, p. 137
Haustorius arenarius Paulmier, 1905, p. 157, fig. 25 ?

Material Examined

1. Keppoch Beach, near Charlottetown, Queens Co., P.E.I., LW level, July 10, 1960, E.L.B. coll.—female type, male allotype, NMC 2311; 11 males, 5 females (ovig.), 4 imm. Paratypes, NMC 2312.
2. Tracadie Harbour, Queens Co., P.E.I., LW level, sandy channel, July 13, 1960, E.L.B. coll.—8 males, 4 ovig. females, 1 fem. br. I, 1 imm., 180 juv. NMC 2313.
3. Panmure Island, Kings Co., P.E.I., sandy shore at LW level, July 24, 1960, E.L.B. coll.—one male, one imm. NMC 2314.
4. Conway Narrows, Prince Co., P.E.I., outer sandy shore, LW level, July 7, 1958, E.L.B. coll.—3 juv. specimens (2 to 3 mm). NMC 2315.

Description

Female (7.5 to 12.0 mm): Body very broad, pleosome with sharp dorso-lateral shelf, urosome strongly inflexed, segments free. Head more or less rectangular, width 1½ times length; rostrum short, triangular, extending a little forward of the acute lateral corners. Eyes small, round, poorly pigmented, and near lateral angles in very juvenile specimens, lacking entirely in adult specimens. Antenna 1, flagellum shorter than peduncle. 8- to 10-segmented, 4 to 5 distal segments with calceoli; accessory flagellum 3- to 4-segmented; peduncular segment 2, anterior and posterior groups of raggedly plumose setae set fanwise on outer surface. Antenna 2, posterior lobe of peduncular segment 4 extends distally beyond junction with segment 5; segment 5 broad, nearly as wide as long; flagellum 9 to 10 segmented, proximal three segments bearing long plumose setae behind.

Mandible, incisor bicuspate, lacinia simple, bladelike; spine row with about 8 slender blades; terminal segment of palp with 11 or 12 slender apical spines, gently curved distally. Lower lip, inner lobes large, elongate. Maxilla 1, inner plate with 16 apical setae, outer plate with 16 stout spines; palp with outer distal row of plumose setae; basal expansion large, oval, heavily ciliated. Maxilla 2, outer lobe large, lunate, length about 2½ times width, outer margin lined with rather long fine hairs. Maxilliped, inner plate rather narrow, outer plate abruptly broadest in middle; terminal (3rd) segment of palp strongly geniculate, horizontal lobe longer than slender axial stem.

Gnathopod 1 simple, powerful; proximal anterior margin of segment 2 distinctly concave; segment 4 strong, lined below with setae and pectinate spines, largest distally; dactyl small, gently curved. Gnathopod 2 minutely chelate, segments slender. Peraeopods 1 and 2 powerfully fossorial, subequal; peraeopod 1, posterior margin of segment 2 with few long plumose setae. Peraeopod 3 only two-thirds the length of peraeopod 4, posterior margin of segment 2 setose; outer face of segment 4 with relatively few spines in each group. Peraeopod 4 slightly longer than peraeopod 5

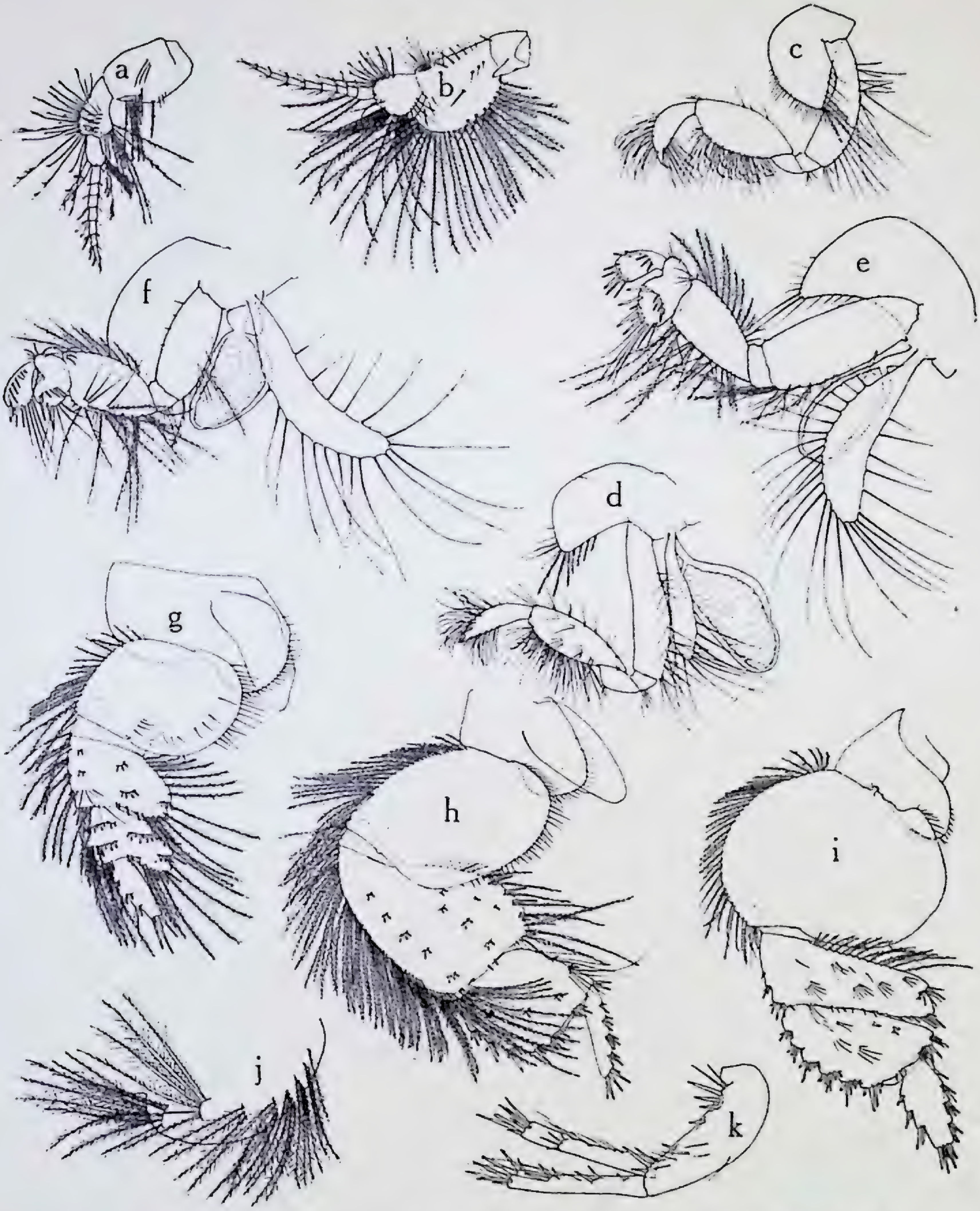

FIGURE 3. *Haustorius canadensis* n. sp., Keppoch Beach, P.E.I. Female TYPE, 8.0 mm: (a) antenna 1, (b) antenna 2, (c) gnathopod 1, (d) gnathopod 2, (e) peraeopod 1, (f) peraeopod 2, (g) peraeopod 3, (h) peraeopod 4, (i) peraeopod 5, (j) abdominal side plate 3, (k) uropod 1.

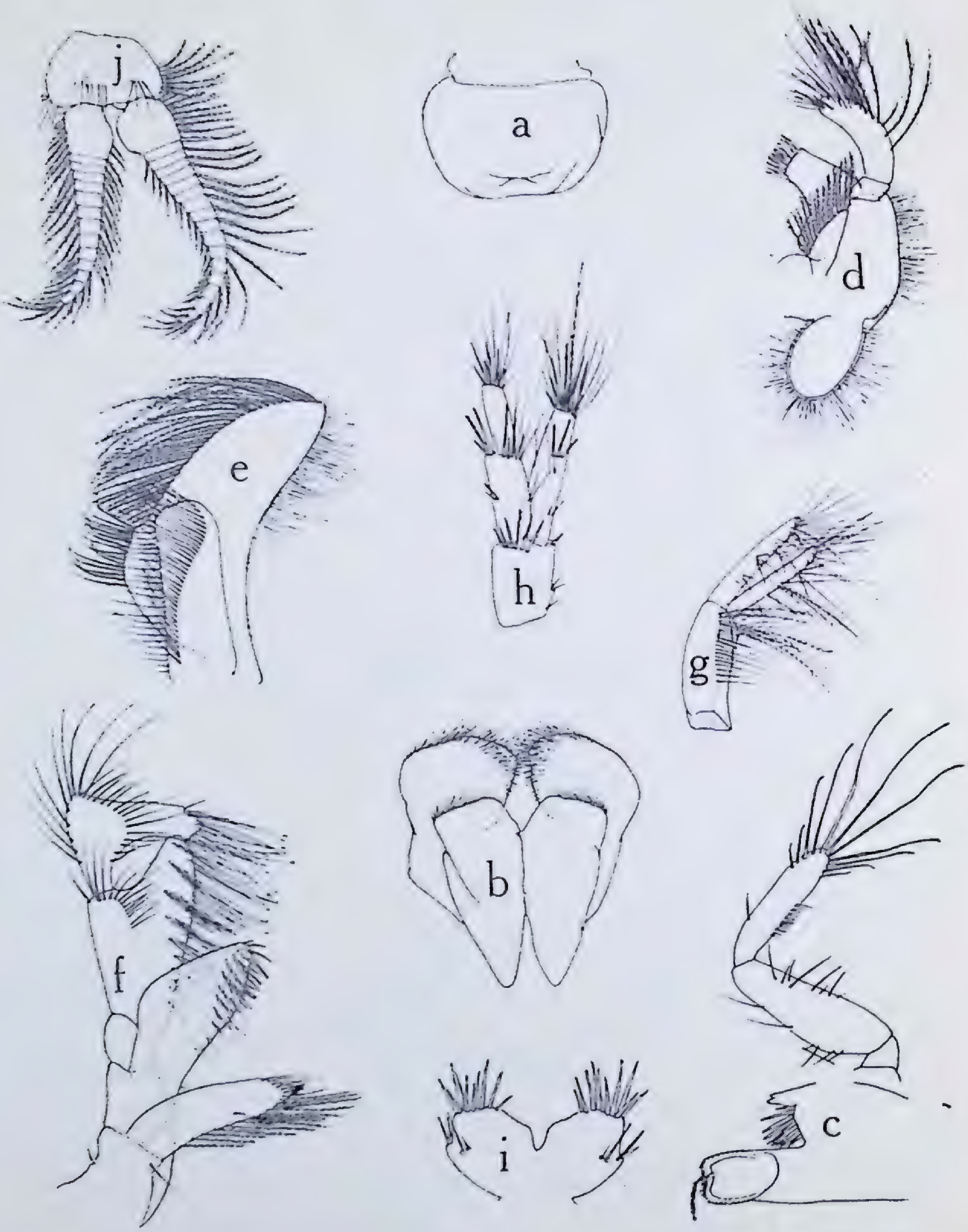

FIGURE 4. *Haustorius canadensis* n. sp., Keppoch Beach, P.E.I. Female TYPE, 8.0 mm: (a) upper lip, (b) lower lip, (c) mandible, (d) maxilla 1, (e) maxilla 2, (f) maxilliped, (g) uropod 2, (h) uropod 3, (i) telson, (j) pleopod 1.

(ratio 9:8); posterior margin of segment 2 nearly straight or slightly concave, setose except distally; segment 4, facial clusters each typically with two spines. Peraeopod 5, segment 4, subrectangular, corners angular, posterior border with one spine group only. Brood plates slender, on segments 2 to 5, very small on 5; setae long, simple. Coxal gills relatively small, tumid, present on peraeon segments 2 to 6.

Abdominal side plate 3, lower margin smoothly rounded behind, armed laterally with 8 or 9 clusters of long plumose setae. Pleopods reduced but powerful; peduncle short and broad; outer ramus longer than inner, both very plumose. Uropod 1, peduncle longer than subequal rami, posterior margin concave, spines clustered proximally and distally; *both rami lined posteriorly with clusters of spines and long setae.* Uropod 2, short peduncle and rami short, subequal, hairy. Uropod 3, outer ramus 2-segmented, slightly longer than inner ramus. Telson cleft apically nearly to middle; posterior margin concave, lateral distal corners each bearing a cluster of 10 stiff spines.

Male (7–11 mm): Very like the female but peraeon much less strongly arched. Antennae 1, 4 or 5 distal flagellar segments bearing elongate calceoli.

Remarks

Material from Keppoch Beach evidently matures at a smaller size than at other localities. This species is closely related to *H. arenarius* and has understandably been confused with it. Perhaps the most significant points of difference, in addition to those given in the key (p. 63–4), are the form of (1) peduncular segment 4 of antenna 2; (2) outer lobe of maxilla 2; (3) inner and outer plates of the maxilliped; (4) segment 2 of gnathopod 1; (5) the telson, and the armature of segment 4, peraeopod 5, and the rami of uropod 1. Paulmier's species conforms quite well with *H. canadensis* in all these features and is tentatively placed here; however, final determination awaits rigorous examination of extensive series of material from the New England States and New York region. To date the species here described has not authentically been taken outside Canadian waters, hence the specific name.

3. **Haustorius spinosus** n. sp.

(Figs. 5 and 6)

syn: *Haustorius arenarius* Bousfield and Leim, 1960.

Material Examined

1. Sandy Cove, Digby County, Nova Scotia, sand beach at LW level. July 8, 1958, E.L.B. coll.—Female type, NMC 2316; Female, 4 imm. paratypes, NMC 2317.
2. Mispec Beach, St. John Co., New Brunswick, sand shore at LW level. August 16, 1958, E.L.B. coll.—4 ♀♀ (1 ovig.), 1 ♂ + 3 imm. NMC 2318.
3. West Quaco, St. John Co., New Brunswick, sand beach at LW level, near Quaco Head, August 15, 1961, E.L.B. coll.—3 males, 2 fem. (ovig.), 3 imm., 3 juv. NMC 2319.

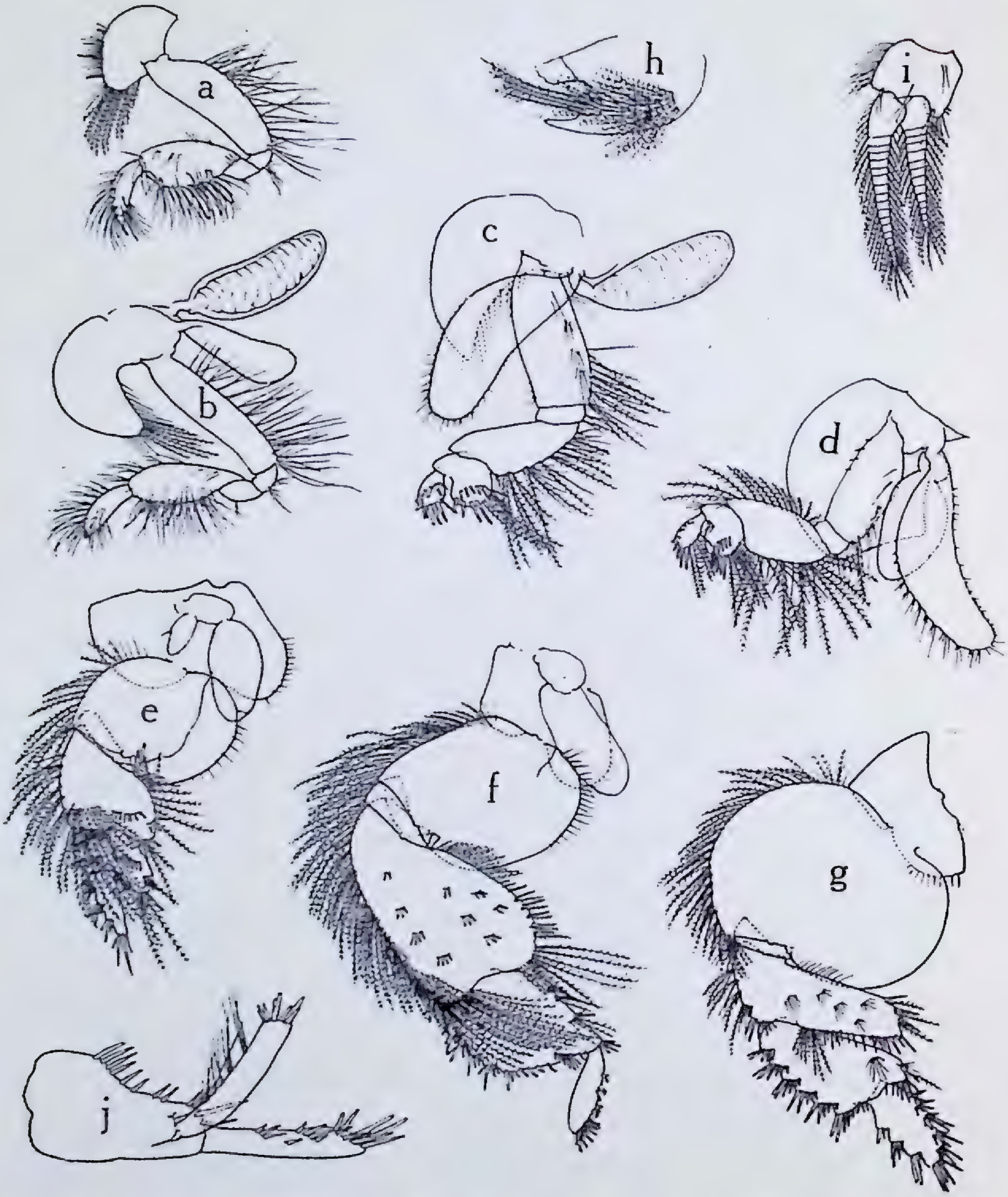

FIGURE 5. *Haustorius spinosus* n. sp., Sandy Cove, N.S. Female TYPE, 12 mm: (a) gnathopod 1, (b) gnathopod 2, (c) peraeopod 1, (d) peraeopod 2, (e) peraeopod 3, (f) peraeopod 4, (g) peraeopod 5, (h) abdominal side plate 3, (i) pleopod 1, (j) uropod 1.

Description

Female (11.5 mm): Body broad and powerful; pleosome with lateral shelf, urosome strongly inflexed, segments small, free. Head nearly twice as wide as long; rostrum short, triangular, extending little forward of bluntly angular lateral corners. Eyes entirely lacking.

Antenna 1, flagellum 9-segmented, shorter than peduncle; peduncular segments 1 and 2 with numerous long plumose setae set fanwise on lateral surface; accessory flagellum 2-segmented. Antenna 2, posterior lobe of segment 4 extending slightly beyond junction with segment 5; segment 5 longer than wide; flagellum 8 or 9 segmented, shorter than peduncle.

Mandible with simple incisor, lacinia not distinct from spine row of 15 slender blades. Palp elongate, terminal segment with long marginal row of comb spines and about 14 slender apical spines. Lower lip, inner lobes relatively narrow, simple. Maxilla 1, inner plate with 16 plumose setae, outer plate with 16 apical spines; palp with distal lateral row of plumose setae; basal expansion rather small. Maxilla 2, outer plate broad, length not twice the width, outer margin lined with short fine cilia; inner lobe more than half the length of the outer lobe. Maxilliped, inner plate short, outer plate rather broad; palp short, terminal segment geniculate, horizontal lobe about equal to axial stem.

Gnathopod 1 simple; segment 2, anterior margin proximally convex; segment 4 moderately expanded; dactyl small. Gnathopod 2 slender throughout; dactyl and propod forming a minute terminal chela. Paraeopods 1 and 2 subequal, powerfully fossorial; segment 6 in each relatively small. In peraeopod 1, anterior margin of segment 4 is lined with plumose setae (omitted in Fig. 6). Peraeopod 3 short, little more than half peraeopod 4; segment 4 with four groups of lateral spines (not one, as shown). Peraeopod 4 distinctly longer than peraeopod 5 (ratio 5:4); segment 2, posterior margin distally bare of setae; segment 4 relatively narrow, width scarcely half the length. Peraeopod 5, segment 4 subrectangular, upper margin with a few short proximal setae, posterior margin with 2 to 3 groups of long spines and plumose setae; segment 5 relatively narrow. Brood plates present on peraeon segments 2 to 5, smallest on 5. Coxal gills small, cylindrical, on peraeon segments 2 to 6.

Abdominal side plate 3, posterior angle produced backwards as a prominent spine, outer face with 6 or 7 vertical rows of long plumose setae. Pleopods short but powerful; peduncle broad; outer ramus longer than inner, plumose setae short. Uropod 1, peduncle basally broad, posterior margin lined with stout spines; rami subequal, inner ramus armed with clusters of setae, outer with spines. Uropod 2, rami and peduncle subequal, setose, a few setae plumose. Uropod 3, outer ramus 2-segmented, slightly longer than inner ramus. Telson very broad, posterior margin convex, shallowly notched, lined across with long stiff setae.

Male (7–9 mm): Antenna 1 apparently without calceoli in material examined.

Remarks

The long spinous process of the 3rd epimeral plate is distinctive, hence the specific name. On re-examination, the three immature specimens

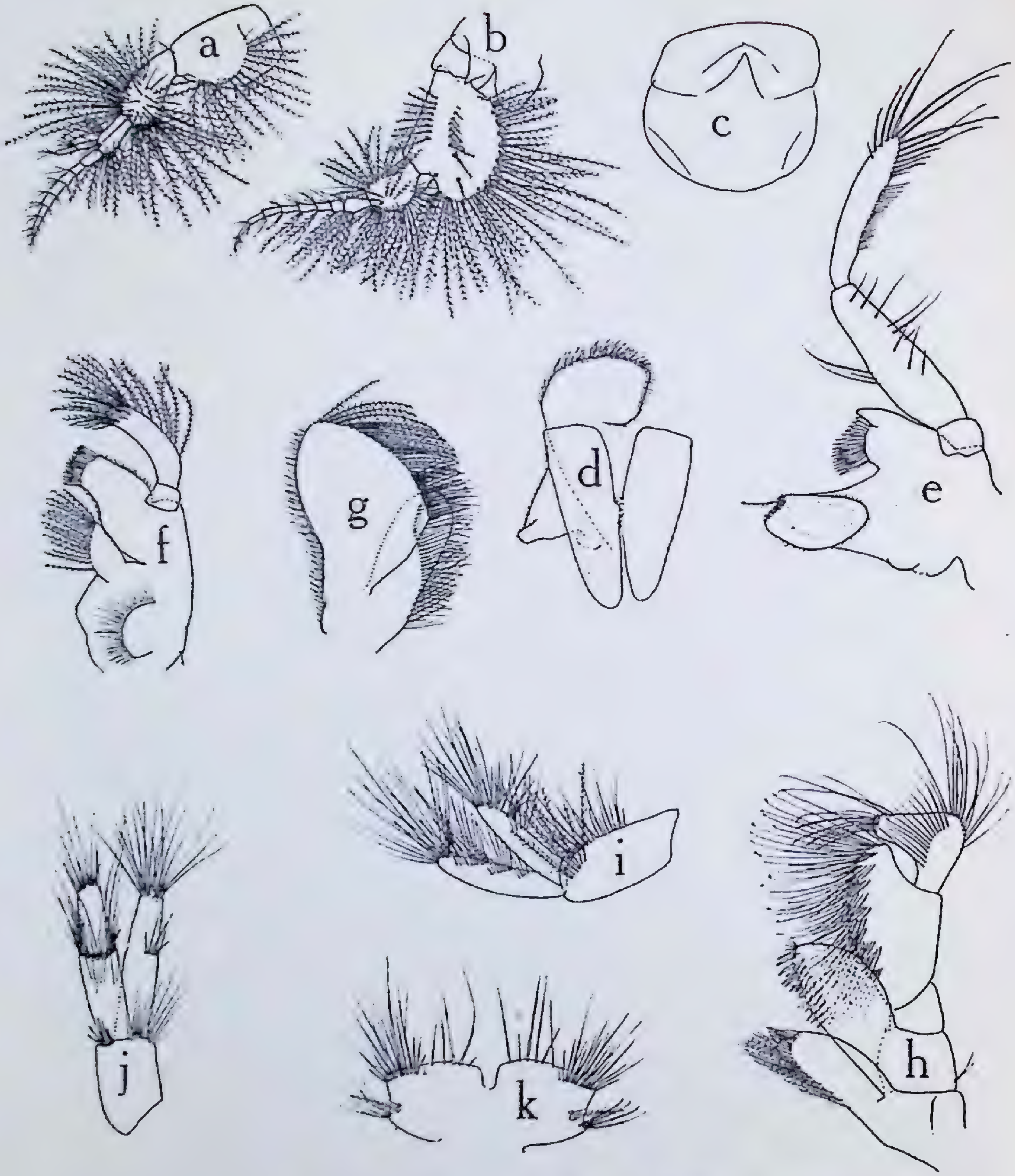

FIGURE 6. *Haustorius spinosus* n. sp., Sandy Cove, N.S. Female TYPE, 12.0 mm: (a) antenna 1, (b) antenna 2, (c) upper lip, (d) lower lip, (e) mandible, (f) maxilla 1, (g) maxilla 2, (h) maxilliped, (i) uropod 2, (j) uropod 3, (k) telson.

from Spencer's Island, Minas Channel (Bousfield and Leim, 1960), were found to be this species. To date it has not been taken outside the Fundy region and is probably subtidal in habitat.

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STATION LIST OF THE NATIONAL MUSEUM MARINE BIOLOGICAL EXPEDITION TO SOUTHEASTERN ALASKA AND PRINCE WILLIAM SOUND

By E. L. Bousfield and D. E. McAllister

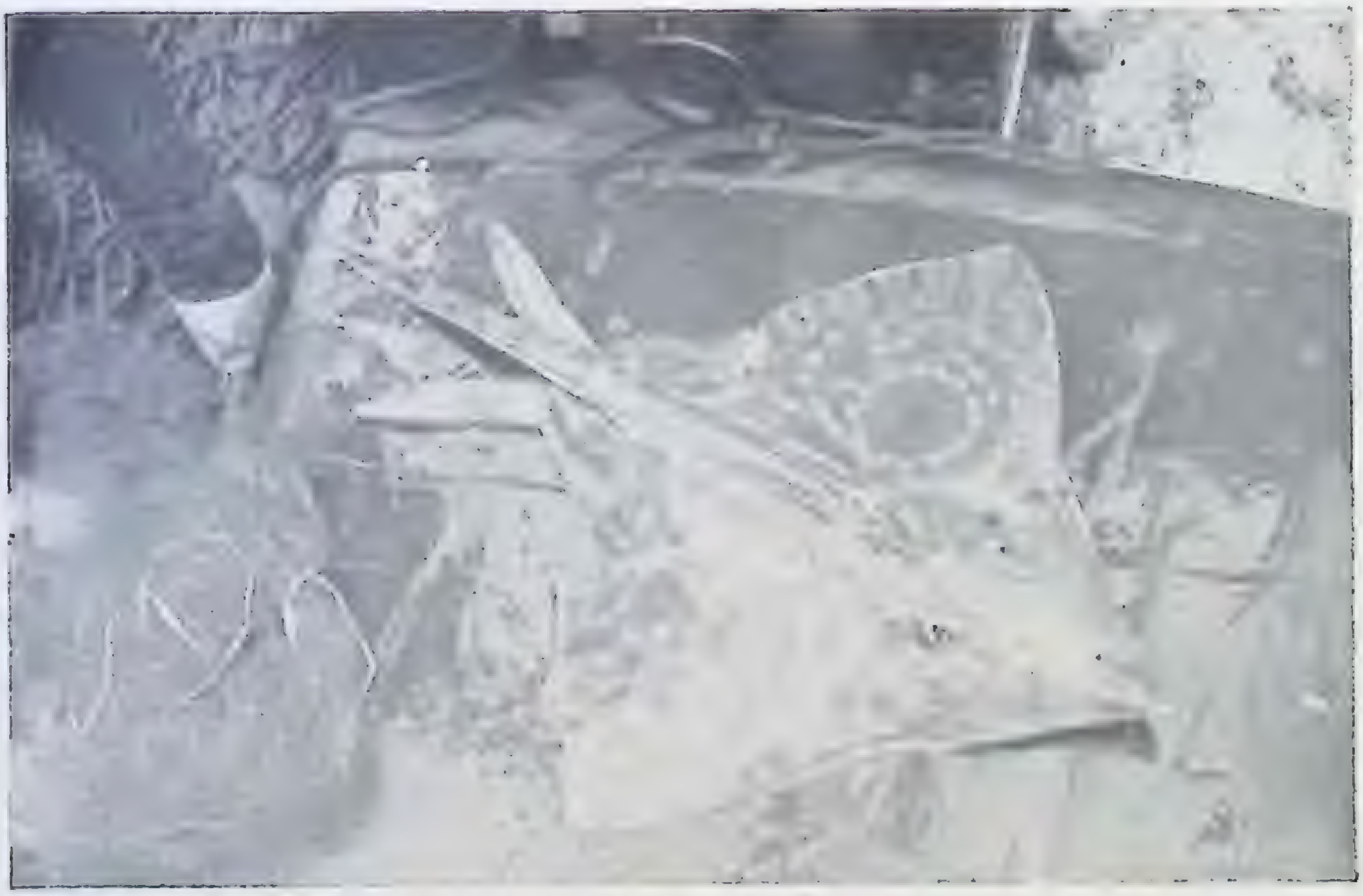
INTRODUCTION

During the period May 25 to August 1, 1961, a marine biological expedition of the National Museum of Canada was carried out in the coastal waters of southeastern Alaska and the Prince William Sound region. The purpose of the expedition was threefold: to obtain, for Museum research collections, marine invertebrate animals and fishes from this rich but poorly known North American region; to study the environmental conditions under which the animals live; to link up recent knowledge of the Canadian Pacific littoral marine fauna with that of the relatively well-known Siberian and Japanese regions. The personnel of the expedition included the senior author as invertebrate zoologist and leader of the party, the junior author as ichthyologist, Mr. J. W. Scoggan of Ottawa as field assistant, and Mr. I. M. Stauffer of Alert Bay, B.C., owner and captain of the 37-foot research vessel *Miss Mel* chartered for the survey. During the nine-week period, the operation covered more than 4,500 miles of coastal waters, established 207 stations, and resulted in the collection of more than 500 species of invertebrates and 100 species of fishes. The material was subsequently sorted into major systematic categories awaiting further study, and the results are expected to appear in a forthcoming series of papers. In order to avoid unnecessary repetition of information for each separate publication, and in accordance with modern practice, the station list and maps of station locations are published here.

Methods of collecting biological specimens depended largely upon the type of fauna and its accessibility. The bulk of the collecting was carried out between the tide lines, but some lots were obtained on land and in fresh water. Dip-nets, seines, sieves, and hand-picking were usefully employed in these instances. Deeper waters (down to 400 ft.) were sampled by means of a standard 3-foot iron frame dredge, a 16-foot beam trawl of the type used by shrimp fishermen, a 6-inch Ekman bottom sampler, monofilament nylon gill-nets, and various fishing lures. Surface temperatures were recorded by means of a mercury thermometer accurate to the nearest 0.1°C, and surface salinities were calculated from float hydrometer readings of specific gravity, accurate to the nearest 0.0001 gm/cc. Depths were estimated visually or with lines in shallow waters and when in deeper water read off directly from the vessel's echo sounder.

The collecting stations are listed in chronological order of establishment. Each station is given a map number for ease of location on maps 1 to 5 (pp. 99-103). Field numbers "A- " indicate invertebrate collections, and field numbers "NMC 61- " indicate fish collections; where both types of collections were made, the latter number is placed in parentheses.

A. Research vessel *Miss Mel* approaching the entrance to Prince William Sound, June 27, 1961.



B. Big skate (*Raja binoculata* Girard) taken in gill-net at head of Dixon Harbour, June 22, 1961, 50 inches long, not kept. Map sta. 75-A.

A considerable number of invertebrates resulted from fish-collecting methods, either directly as impedimenta on nets or trawl meshes, or indirectly as food items or parasites of the fishes taken. Conversely, fishes, particularly the smaller species, were frequently taken during the collection of shallow-water invertebrates using dip-nets and fine sieves. Other headings of the list are self-explanatory.

ACKNOWLEDGMENTS

The expedition owes its success in large part to the assistance of several governmental departments and interested persons. Chief among these are the United States Coast Guard, the Customs and Immigration departments of both the United States and Canada, and the Alaska Department of Fish and Game. The authors are particularly grateful to Mr. Wally Noerenberg, Mr. Dave Savoie, and Mr. Harry Curran of the Alaska Fish and Game Department at Cordova, and to Mr. Richard Haley of the same department at Seward, Alaska. The useful information on collecting sites, transportation to local areas of interest, unusual biological specimens from the region, and warm-hearted hospitality provided by these officials will long be remembered by members of the expedition. Mr. John Scoggan very ably assisted with the field work, and Mr. Mel Stauffer has earned our gratitude not only for his extraordinary skill as a navigator and fisherman, but also for his culinary ability and good companionship.

STATION LIST

Map Sta.	Station	Date	Locality	Latitude and Longitude	Habitat	Collecting Methods	emp. °C	Sal'y.⁰/₀₀	Depth
1	A-1 (NMC61-4)	30 May	n. of Essowah Pt., Dall I.	54° 46′ 132° 54′	creek mouth, gravel and stones	dip-net	13.8	variable	MW to HW
2	A-2 (NMC61-5)	30 May	Little Daykoo, Dall I.	54° 42′ 132° 42′	tidepools, slate bed-rock	dip-net	11.3	—	MW to HW
3	A-3 (NMC61-6)	31 May	Little Daykoo, Dall I.	54° 42′ 32° 42′	tidepools, slate bed-rock	dip-net	9.7	30.0	LW to MW
4	NMC61-7	30–31 May	Little Daykoo, Dall I.	54° 42′ 132° 42′	rocky reef	gill-net	9.7	—	20–40 ft.
5	A-4	31 May	Brownson Inlet, Prince of Wales I.	54° 45′ 132° 15′	mouth, freshwater stream, boulders	dip-net	15.3	variable	HW
6	A-5 (NMC61-8)	31 May	Pt. e. of Pt. Marsh, Prince of Wales I.	54° 43′ 132° 17′	tidepools and spray pools	dip-net	*ca.* 12	—	MW to HW
7	NMC61-9	31 May-1 June	Brownson B., Prince of Wales I.	54° 45′ 132° 14′	200 yards off rocky shore	gill-net	9.8	—	—
8	A-6 (NMC61-10 NMC61-11)	1 June	Pt. e. of Pt. Marsh, Prince of Wales I.	54° 43′ 132° 17′	tidepools and under stones	dip-net	9.5	30.0	LW to MW
9	NMC61-12	1–2 June	s.w. Bostwick B., Gravina I.	55° 13′ 131° 44′	off beach	gill-net	11.8	—	30–36 ft.
10	A-7 (NMC61-13 NMC-61-14 NMC61-15)	2 June	s.w. Bostwick B., Gravina I.	55° 13′ 131° 44′	boulder and rock, sand and mud beach, eelgrass	dip-net	11.8	24.8	LW to HW

STATION LIST—*Cont.*

Map Sta.	Station	Date	Locality	Latitude and Longitude	Habitat	Collecting Methods	Temp. °C	Sal'y.‰	Depth
11	A-8 (NMC61-16)	3 June	Tongass Ch., opp. Ketchikan	55° 20′ 131° 39′	rocky shore, coarse sand beach, mouth of stream	dip-net	11.8	27.0	LW to HW
12	NMC61-17	3-4 June	Anan B., Bradfield Canal	56° 12′ 131° 49′	rock and weed bottom	gill-net	—	—	20-30 ft.
13	A-9 (NMC61-18)	4 June	Anan B., Bradfield Canal	56° 12′ 131° 49′	under stones in stream mouth	dip-net	6.0	variable	MW to HW
14	A-10	4 June	Anan B., Bradfield Canal	56° 12′ 131° 49′	under log and in moss	hand	—	—	terrestrial
15	A-11 (NMC61-19)	4 June	head of Bradfield Canal	56° 13′ 131° 33′	muddy sand flats, river mouth	dip-net	8.1	3.9	LW
16	NMC61-20	5 June	Eastern Passage off Stikine R. mouth	56° 30′ 132° 20′	mud bottom	jigging	—	—	30 ft.
17	A-12 (NMC61-21)	5 June	Eastern Passage, just s. of Stikine R. mouth	56° 30′ 132° 19′	mud and stones	dip-net	9.8	2.2	LW to HW
18	A-13 (NMC61-22)	5 June	2 mi. n.w. Pt. Highfield, n. end Wrangell I.	56° 30′ 132° 27′	mud	beam trawl	—	—	150-210 ft.
19	A-14	6 June	Red B., northern end Prince of Wales I.	56° 19′ 133° 17′	sand	dip-net	—	—	HW
20	A-15 (NMC61-23 NMC61-24)	6 June	Island s. of North I., Port Mac-Arthur B., Kuiu I.	56° 35′ 134° 65′	tidepool, rocky cove	dip-net	10.7	29.7	LW to HW

21	A-16 (NMC61-24-A)	6 June	s. side Port MacArthur B., Kuiu I.	56° 35' 134° 65'	sand and shell with boulders	dip-net	—	—	LW
22	A-17	7 June	off North Rock, Baranof I.	56° 35' 134° 65'	pelagic	dip-net	—	—	surface
23	A-18 (NMC61-25 NMC61-26)	7 June	Tava I., near Sitka	56° 50' 135° 29'	tidepools, eelgrass and sand	dip-net	11.3	32.7	LW to HW
24	A-19 (NMC61-27)	8 June	Sitka, Baranof I.	57° 3' 135° 20'	eelgrass and sand, tidepools in bed-rock	dip-net	9.9	18.4	LW to MW
25	A-20 (NMC61-28)	8 June	Sitka	57° 3' 135° 20'	wharf	jigging	*ca.* 10	—	25 ft.
26	A-21 (NMC61-29)	8 June	Sitka Sd.	57° 2' 135° 32'	sand and stone bottom	beam trawl	—	—	120–150 ft.
27	A-22 (NMC61-30 NMC61-31)	8 June	s.e. Kruzof I., near Sitka	57° 1' 135° 37'	tidepools in lava, blacksand, stream mouth	dip-net	10	—	LW to HW
28	A-23 (NMC61-32)	9 June	s. side of Kakul Narrows, Baranof I.	57° 22' 135° 41'	slate rock, broken shells	dip-net	8.0	29.9	LW to HW
29	A-24 (NMC61-33)	9 June	n.e. Bradshaw Cove, Chichagof I.	57° 23' 135° 40'	rock bottom	jigging	8.0	—	—
30	A-25 (NMC61-33-A)	9 June	Hanus B., Baranof I.	57° 24' 135° 1'	bed-rock and coarse sand	dip-net	*ca.* 8	—	LW to HW
31	A-26	9 June	Hanus I. Baranof I.	57° 24' 135° 1'	under moss and bark	hand	—	—	terrestrial
32	A-27 (NMC61-34)	10 June	stream, Hanus B.	57° 24' 135° 1'	mud and gravel flats	dip-net	8.0	29.0	LW to HW

Station List—*Cont.*

Map Sta.	Station	Date	Locality	Latitude and Longitude	Habitat	Collecting Methods	Temp. °C	Sal'y.°/₀₀	Depth
33	NMC61-35	10 June	Tyee Cannery, Murder Cove, Admiralty I.	57° 2′ 134° 33′	mud	jigging	—	—	84 ft.
34	A-28	10 June	Tyee Cannery, Murder Cove, Admiralty I.	57° 2′ 134° 33′	pelagic	dip-net	—	—	surface
35	A-29	10 June	Tyee Cannery, Murder Cove, Admiralty I.	57° 2′ 134° 33′	gravel beach	hand	—	—	HW
36	A-30 (NMC61-36)	11 June	Tyee Cannery, Murder Cove, Admiralty I.	57° 2′ 134° 33′	muddy sand, bedrock, tidepools, gravel	dip-net	8.2	29.3	LW to HW
37	NMC61-37	11 June	Tyee Cannery, Murder Cove, Admiralty I.	57° 2′ 134° 33′	off rock point	jigging	8.2	—	15 ft.
38	A-31	11 June	Fanshaw B.	57° 12′ 133° 32′	blacksand, gravel	hand	10.1	—	HW drift
39	NMC61-38	11 June	Holkham B., Stephens Passage	57° 43′ 133° 36′	—	jigging	8.8	—	72 ft.
40	A-32	12 June	Wood Spit, Holkham B.	57° 44′ 133° 36′	boulders and coarse sand	dip-net	6.3	—	LW
41	A-33 (NMC61-39)	12 June	spit off Sumdum Glacier	57° 46′ 133° 36′	stones and fine sand	dip-net	6.3	29.9	LW to MW
42	NMC61-40	12 June	Juneau	58° 18′ 134° 25′	wharf	jigging	—	—	60 ft.

43	A-34 (NMC61-41)	13 June	Taku Inlet near Flat Pt.	58° 20′ 134° 5′	silt and rock	dip-net	7.7-8	4.9	LW
44	A-35 (NMC61-42)	13 June	Juneau	58° 18′ 134° 25′	wharf	jigging	—	—	72 ft.
45	A-36 (NMC61-43)	14 June	Juneau	58° 18′ 134° 25′	wharf	jigging	—	—	72 ft.
46	A-37 (NMC61-44)	15 June	Gastineau Passage, n. of Juneau	58° 21′ 134° 30′	mud and sand, salt marsh	seine and dip-net	7.3	8.4	LW to HW
47	NMC61-45	15 June	Gastineau Passage, n. of Juneau	58° 21′ 134° 30′	sand spit	seine	7.3	—	LW
48	A-38 (NMC61-46)	15 June	Gastineau Passage at Douglas	58° 16′ 134° 22′	sand	seine and dip-net	—	—	MW to HW
49	A-39	15 June	Young B., Admiralty I.	58° 10′ 134° 37′	slate, sand, and stone	hand	10	—	HW drift
50	NMC61-47	15 June	Young B., Admiralty I.	58° 12′ 134° 36′	mud	beam trawl	—	—	201-210 ft.
51	A-40 (NMC61-48)	15 June	Young B., Admiralty I.	58° 12′ 134° 36′	mud	beam trawl	—	—	255-262 ft.
52	A-41	15 June	Tee Harbour, Lynn Canal	58° 26′ 134° 47′	mud	jigging	—	—	42 ft.
53	A-42 (NMC61-49)	16 June	near mouth Herbert R., Lynn Canal	58° 31′ 134° 50′	sand	jigging Ekman dredge	—	—	60 ft.
54	A-43 (NMC61-50 NMC61-51)	16 June	near mouth Herbert R., Lynn Canal	58° 31′ 134° 50′	sand, rocky shore	seine and dip-net	10	22.3	LW to HW

STATION LIST—*Cont.*

Map Sta.	Station	Date	Locality	Latitude and Longitude	Habitat	Collecting Methods	Temp. °C	Sal'y.‰	Depth
55	A-44	16 June	Lynn Canal	58° 19′ 135° 0′	pelagic	salinity sample	11.5	29.3	surface
56	A-45 (NMC61-52)	16 June	Rocky I., Icy Str.	58° 10′ 135° 3′	off rocky islet	jigging	11.4	—	42–210 ft.
57	A-46 (NMC61-53)	16 & 17 June	Halibut Rock, Port Frederick, Icy Str.	58° 8′ 135° 29′	rocky reef	jigging	—	—	98–180 ft.
58	A-47	17 June	inside Halibut I., Port Frederick, Icy Str.	58° 9′ 135° 29′	mud and debris	Ekman dredge	—	—	72 ft.
59	A-48 (NMC61-54)	17 June	Scraggy I., Icy Str.	58° 10′ 135° 28′	sand, gravel, under stones	seine, dip-net	10.1	29.6	LW to HW
60	NMC61-55	17 June	Scraggy I., Icy Str.	58° 10′ 135° 28′	at surface, among kelp fronds	dip-net	10.1	—	water depth 10–15 ft.
61	A-49	17 June	Porpoise I., Icy Str.	58° 19′ 135° 31′	gravel spit	hand	—	—	HW drift
62	A-50 (NMC61-56)	17 June	between Porpoise and Pleasant I., Icy Str.	*ca.* 58° 20′ *ca.* 135° 30′	mud	jigging	—	—	132 ft.
63	A-51	17 June	Noon Pt., Pleasant I., Icy Str.	58° 19′ 135° 32′	gravel and rock	hand	—	—	HW pools and drift

64	A-52 (NMC61-57)	17 June	Willoughby Cove, Lemesurier I., Icy Str.	58° 16′ 136° 2′	bryozoan and rock bottom	jigging	—	—	42 ft.
65	A-53 (NMC61-58)	18 June	Taylor B., Icy Str.	58° 17′ 136° 30′	—	floating on surface	—	—	360 ft.
66	A-54 (NMC61-59)	18 June	head Taylor B., Icy Str.	58° 21′ 136° 36′	sand	dip-net, seine	9.7	21.9	LW to HW
67	A-55	18 June	w. side Taylor B., Icy Str.	58° 21′ 136° 36′	boulder and clay, silt	dip-net	—	—	LW to HW
68	NMC61-60	18 June	pt. w. side Taylor Bay, Icy Str.	58° 21′ 136° 36′	freshwater pond	dip-net	*ca.* 15	—	1 ft.
69	A-56 (NMC61-61)	18 June	Cross Sd., ¾ mi. from Pt. Lavinia	58° 13′ 136° 23′	pelagic rock bottom	jigging dip-net	—	—	surface and 90–210 ft.
70	NMC61-62	18 June	Elfin Cove, Chichagof I.	58° 11′ 136° 21′	wharf	jigging	—	—	12 ft.
71	A-57 (NMC61-63 NMC61-64)	19 June	Dixon Harbour, Sugarloaf I.	*ca.* 58° 19′ 136° 51′	among kelp, boulders and sand, tidepools	dip-net	9.9	30.8	LW to HW
72	A-58 (NMC61-65)	19 June	river mouth Dixon Harbour	58° 22′ 136° 50′	sand beach, river mouth	seine, hand	—		MW to HW
73	NMC61-66	19 June	Dixon Harbour, northeastern Sugarloaf I.	58° 19′ 136° 51′	rock bottom	jigging	9.9	—	36 ft.
74	A-59	20 June	pond, Thistle Cove, Dixon Harbour	58° 22′ 136° 51′	mountain pond and stream	dip-net	11.3 (pond) 6.3 (stream)	—	*ca.* 400 ft. altitude
75	A-60 (NMC61-67)	20 June	Thistle Cove, Dixon Harbour	58° 22′ 136° 52′	sand bar	seine	10.1	27.2	LW to HW

STATION LIST—*Cont.*

Map Sta.	Station	Date	Locality	Latitude and Longitude	Habitat	Collecting Methods	Temp. °C	Sal'y.‰	Depth
75 A	NMC61-68	20-22 June	Thistle Cove, Dixon Harbour	58° 22′ 136° 52′	mud bottom	gill-net	10.1	—	25 ft.
76	A-61 (NMC61-69)	21 June	Astrolabe B., Palma B.	58° 23′ 136° 53′	boulder, sand	dip-net	*ca.* 10	—	LW to HW
77	A-62 (NMC61-70)	21 June	Boussole B., Palma B.	58° 24′ 136° 54′	sand and gravel, stream mouth	seine	—	—	HW drift
78	A-63	21 June	Astrolabe B., Palma B.	58° 23′ 136° 53′	bog pond, sphagnum, organic detritus	dip-net	—	—	*ca.* 300 ft. altitude
79	A-64	22 June	Thistle Cove, Dixon Harbour	58° 22′ 136° 52′	glacial silt	Ekman dredge	—	—	25 ft.
80	NMC61-71	22 June	s.w. Lituya B.	59° 33′ 139° 44′	—	jigging	9.9	—	*ca.* 360 ft.
81	A-65	22 June	s. shore mouth of Lituya B.	58° 32′ 137° 38′	sand and boulders	hand	9.8	25.4	HW
82	A-66	22 June	1½ mi. s. Lituya B.	58° 30′ 137° 38′	sand	hand	—	—	HW drift
83	A-67 (NMC61-72)	24 June	Head Monti B., Yakutat	59° 33′ 139° 44′	sand and boulders	seine and dip-net	10.0	27.5	LW
84	A-68 (NMC61-73)	24 June	Yakutat roads, near Mission, Yakutat	59° 33′ 139° 45′	sand, gravel, boulders	seine and dip-net	10.4	27.2	LW to HW

85	NMC61-74	24 June	Yakutat	59° 33′ 139° 41′	wharf	jigging	*ca.* 10	—	20–30 ft.
86	A 69 (NMC61-75)	24 June	Monti B., outside Yakutat roads	59° 33′ 139° 47′	sand and a few stones, kelp fragments	dredge	—	—	120–180 ft.
87	A-71 (MNC61-76)	25 June	Ankau "creek," Monti B.	59° 32′ 139° 46′	sand, stones	seine and dip-net	10.2	26.6	LW to HW
88	NMC61-77	24–25 June	Monti B. off Ankau "creek"	59° 32′ 139° 46′	sand	gill-net	10.2	—	50 ft.
89	A-72 (NMC61-78)	25 June	Icy B.	59° 55′ 141° 32′	mud	beam trawl	—	—	186–210 ft.
90	A-73 (NMC61-79)	26 June	Icy B.	59° 55′ 141° 20′	sand and silt, boulders	dip-net and seine	8.3	24.3	LW to HW
91	A-74 (NMC61-80)	26 June	channel between Wingham and Kayak I.	59° 59′ 144° 21′	sand	jigging Ekman	—	—	30 ft.
92	A-75 (NMC61-81)	27 June	Kayak, Wingham I.	59° 59′ 144° 22′	boulders, muddy gravel	dip-net and hand	11.3	30.6	LW to HW
93	A-76 (NMC61-82)	27 June	Port Etches, Hinchinbrook I.	60° 20′ 146° 37′	fine mud	beam trawl	—	—	186–198 ft.
94	A-77	27 June	n.e. side Port Etches	60° 20′ 146° 39′	gravel beach	hand	—	—	HW drift
95	A-78 (NMC61-83)	27 June	Nuchek, Hinchinbrook I.	60° 20′ 146° 39′	freshwater lagoon	dip-net and seine	*ca.* 15	—	+ 2 ft.
96	NMC61-84	27–28 June	Constantine Harbour, Hinchinbrook I.	60° 21′ 146° 39′	mud	gill-net	13.8	—	10–25 ft.

STATION LIST—*Cont.*

Map Sta.	Station	Date	Locality	Latitude and Longitude	Habitat	Collecting Methods	Temp. °C	Sal'y.‰	Depth
97	A-79 (NMC61-85)	28 June	Constantine Harbour, Hinchinbrook I.	60° 20′ 146° 39′	mud and shells, gravel, eelgrass	dip-net and seine	13.0	27.8	LW
98	A-80 (NMC61-86)	28 June	beach Nuchek, Hinchinbrook I.	60° 20′ 146° 39′	tidepools, slate, gravel and rock	dip-net and seine	12.8	26.6	LW to HW
99	A-81 (NMC61-87)	29 June	Orca Inlet, Hawkins I.	60° 33′ 145° 48′	sand flats, eelgrass, rock	dip-net and seine	9.8	28.2	LW
99a	(NMC61-88)	24 Mar.	ck. Sheep B.	60° 30′ 145° 54′	ck. mouth, tidal	—	—	variable	—
100	A-82 (NMC61-89)	29 June	Eyak L., Cordova	60° 32′ 145° 40′	gravel, boulders, sand, mud, detritus	dip-net and seine	9 to 18	fresh	*ca.* 10 ft. altitude
101	NMC61-90	28–29 June	Cordova	60° 32′ 145° 45′	sandy mud	jigging	—	—	20–35 ft.
102	A-83 (NMC61-91)	30 June	mouth Cordova R., Cordova B., head of Orca Inlet	60° 40′ 145° 36′	silt and gravel	seine and dip-net	9.6	14.3	LW
103	A-84 (NMC61-92)	30 June	Orca Inlet opp. Shepard Pt.	60° 38′ 145° 41′	mud	beam trawl	9.6	—	168–180 ft.
104	A-85 (NMC61-93)	30 June 1 July	Sheep B.	60° 41′ 145° 59′	rock reef	gill-net	14.7	—	40–50 ft.
105	A-86 NMC61-94)	1 July	bay on w. side of island, Sheep B.	60° 40′ 145° 59′	sandy mud, shells, eelgrass	seine and dip-net	14.3	20.5	LW to HW
106	NMC61-95	1 July	Sheep B.	60° 40′ 146° 1′		jigging	—	—	48 ft.

107	A-87 (NMC61-96)	1 July	s. side of island, Sheep B.	60° 40′ 146° 0′	mud, sand, gravel, eelgrass	seine and dip-net	14.1	—	LW to HW
108	A-88	1 July	Gravina Pen., near Gravina Pt.	60° 38′ 146° 11′	gravel bottom mouth lagoon	dip-net	—	—	MW to HW
109	A-89	1 July	Gravina Pen., near Gravina Pt.	60° 38′ 146° 11′	gravel beach	hand	—	—	HW drift
110	A-90	1 July	s.e. of Gravina Pt.	60° 40′ 146° 11′	mud and kelp holdfast	anchor	—	—	18 ft.
111	A-91 (NMC61-97)	2 July	pt. between Olsen and Parshas B., Port Gravina	60° 44′ 146° 10′	eelgrass, sand, gravel, rock	seine and dip-net	13.7	21.6	LW
112	A-92 NMC61-98)	2 July	just s. of Comfort Cove, Port Gravina	60° 43′ 146° 7′	sand and gravel tidepools	seine and dip-net	13.5	17.0	LW to HW
113	A-93	2 July	Gravina R., Port Gravina	60° 47′ 146° 4′	estuary; silt, sand, detritus	dip-net	9.3	—	LW
114	A-94 (NMC61-98A)	2 July	Port Gravina inside Red Head	60° 42′ 146° 20′	gravel beach	hand	—	—	HW drift
115	A-95 (NMC61-99)	2–3 July	w. half Two Moon Bay	*ca.* 60° 45′ *ca.* 146° 33′	sand and mud	baited trap jiggig	13.3	—	48 ft.
116	A-96	3 July	mouth e. half of Two Moon B.	60° 46′ 146° 31′	black sand, eelgrass, stones	dip-net	13.5	28.4	LW
117	A-96A	3 July	e. half of Two Moon B. near head	60° 45′ 146° 30′	gravel and sand	shovel	—	—	MW to HW
118	NMC61-99A	4 July	Valdez Narrows	61° 4′ 146° 40′	gravel	jigging hand	—	—	40 ft.
119	A-97 (NMC61-99B)	4 July	Valdez Narrows	61° 4′ 146° 40′	beach	hand	—	—	HW drift terrestrial

STATION LIST—*Cont.*

Map Sta.	Station	Date	Locality	Latitude and Longitude	Habitat	Collecting Methods	Temp. °C	Sal'y.‰	Depth
120	A-98 (NMC61-100)	4 July	mouth Sawmill B., Valdez Arm	60° 2′ 146° 47′	gravel, boulders	dip-net jigging	11.6	5.3	LW, HW 35 ft.
121	A-99 (NMC61-101)	4 July	Sawmill B. near stream	60° 3′ 146° 48′	eelgrass, silt, gravel chips	dip-net and seine	*ca.* 10	—	LW to MW
122	A-100 (NMC61-102)	4 July	1¼ mi. s.w. of Fairmont I.	60° 51′ 147° 27′	rock	jigging	—	—	150 ft.
123	A-101	4 July	Siwash B. near head, Unakwit Inlet	60° 58′ 147° 40′	blue mud	Ekman dredge	—	—	66 ft.
124	A-102 (NMC61-103)	4-5 July	narrows in Siwash B., Unakwit Inlet	60° 57′ 147° 39′	rocky sill	gill-net	—	—	60-70 ft.
125	A-103	5 July	near mouth Siwash B., Unakwit Inlet	147° 38′ 60° 58′	mud and stones, rocky sill	dredge	—	—	66-120 ft.
126	A-104 (NMC61-104)	5 July	mouth Siwash B., Unakwit Inlet	60° 57′ 147° 37′	rock	beam trawl	—	—	84-96 ft.
127	A-105	5 July	spit opposite Jonah B., Unakwit Inlet	61° 1′ 137° 30′	gravel and boulder	dip-net	9.9	24.7	LW
128	NMC61-105	5 July	off Unakwit Inlet	61° 1′ 137° 32′	rock, boulders	jigging	—	—	120 ft.
129	A-106 (NMC61-106)	5 July	bay at mouth of Esther R., Esther I.	60° 48′ 148° 5′	rock	jigging	—	—	30-60 ft.
130	A-107 (NMC61-107)	5-6 July	cove at mouth of Esther R., Esther I.	60° 48′ 148° 5′	rock, eelgrass	gill-net	—	—	0-30 ft.

131	A-108	6 July	Esther L., Esther I.	60° 48′ 148° 5′	rocky bottom and stone chips	dip-net	14.0	fresh-water	1–3 ft. *ca.* 60 ft. alt.
132	A-109	6 July	inside Coghill Pt.	61° 4′ 147° 56	gravel, mud, rock	dip-net	10.8	—	LW
133	A-110	6 July	College Fjord, base of Coghill Pt.	61° 5′ 147° 56′	mud, stones, tidepool	dip-net	—	—	MW to HW
134	A-111 (NMC61-108)	6 July	1 mi. s.w. of Coghill R. mouth	61° 3′ 147° 56′	pelagic	gill-net	10.8	—	surface
135	A-112 (NMC61-109)	7 July	outlet of Eshamy L., Eshamy B.	60° 27′ 148° 6′	stones, boulders, moss, coarse sand	dip-net and hand	12	fresh-water	0–3 ft. *ca.* 10–15 ft. alt.
136	A-113	7 July	mouth of inner Ewan B.	60° 24′ 148° 9′	sandy mud, shells	Ekman	—	—	65 ft.
137	A-114 (NMC61-110)	7 July	mouth of inner Ewan B.	60° 24′ 148° 9′	rock and boulders	dip-net, hand	—	—	0–2 ft. LW
138	NMC61-111	7 July	Thumb B., Knight I.	60° 12′ 147° 47′	—	jigging	—	—	70 ft.
139	A-115 (NMC61-112)	8 July	Little B., Knight I.	60° 10′ 147° 48′	boulders, gravel, eelgrass	dip-net hand	11.4	28.9	LW
140	NMC61-113	8 July	s. side Little B., Knight I.	60° 11′ 147° 47′	boulders?	jigging	11.4	—	36 ft.
141	NMC61-114	8 July	Port Ashton, Evans I.	60° 3′ 148° 3′	wharf	jigging	12.3	27.1	25 ft.
142	A-116 (NMC61-115)	8 July	Erlington Passage	59° 59′ 148° 7′	rock	jigging	—	—	240–300 ft.
143	A-117 (NMC61-116)	8 July	cove s. Erlington I.	59° 58′ 148° 10′	coarse sand	jigging Ekman dredge	12.0	—	20–30 ft.

STATION LIST—*Cont.*

Map Sta.	Station	Date	Locality	Latitude and Longitude	Habitat	Collecting Methods	Temp. °C	Sal'y.‰	Depth
144	A-118	8 July	bar at head North Twin B., Erlington I.	59° 58′ 148° 11′	stones	hand	—	28.0	MW to HW
145	A-119 (NMC61-117)	8 July	cove inside islet, s. Erlington I.	59° 58′ 148° 9′	mud	beam trawl	—	—	150-228 ft.
146	A-120 (NMC61-118)	8 July	near mouth of cove, e. side Puget B.	60° 0′ 148° 29′	rock, *Laminaria*	jigging, gill-net	—	—	30 ft.
147	A-121 (NMC61-119 NMC61-120)	9 July	near head of cove, e. side Puget B.	60° 0′ 148° 29′	boulders, sand, gravel	dip-net and hand	10.4	—	LW to MW
148	A-122 (NMC61-120A)	9 July	near head of cove, e. side Puget B.	60° 0′ 148° 29′	boulder	jigging	10.4	—	20 ft.
149	A-123	9 July	n. side of mouth of cove, e. side of Puget B.	60° 0′ 148° 30′	rock, tidepools	hand	—	—	HW
150	A-124	9 July	e. side near mouth of Puget B.	59° 58′ 148° 29′	sand and stones	dredge trawl	—	—	48–72 ft. 150–210 ft.
151	A-125 (NMC61-121)	9 July	pt. middle of Johnstone B., Blying Sd.	59° 56′ 148° 43′	rock	jigging	—	—	30 ft.
152	A-126 (NMC61-122)	9 July	lagoon, Johnstone B., Blying Sd.	59° 57′ 148° 45′	mud, algae	seine	—	brackish	0–2 ft.
153	A-127	9 July	e. cove Whidbey B., Blying Sd.	59° 51′ 148° 53′	black sand	hand	—	—	HW

154	A-128 (NMC61-123 NMC61-124)	9 July	Anchor Cove, Day Harbour, Blying Sd.	60° 0′ 149° 6′	rock	jigging, gill-net	—	—	0-40 ft.
155	A-129 (NMC61-125)	10 July	e. side Day Harbour, 1 mi. s. of Anchor Cove	59° 59′ 149° 7′	gravel, boulders, algae	hand and dip-net	11.3	29.4	LW
156	A-130 (NMC61-126)	10 July	3 mi. n.e. Bowen Anchorage, Day Harbour	60° 3′ 149° 7′	rock, tidepools, kelp	dip-net	8.8	22.2	LW to HW
157	NMC61-127	10 July	Seward	60° 6′ 149° 26′	wharf	jigging	—	—	24 ft.
158	A-131 (NMC61-128)	11 July	cove n. Renard I., Resurrection B.	59° 56′ 149° 19′	gravel, boulders, *Laminaria*	seine and dip-net	11.3	29.3	LW to HW
159	A-132 (NMC61-129)	11 July	pt. 3 mi. s.w. of Callisto Head, Resurrection B.	59° 54′ 149° 32′	rock, tidepools	dip-net	—	—	MW to HW
160	A-133 (NMC61-130)	11 July	s. end of bay, off Bear Glacier, Resurrection B.	59° 54′ 149° 33′	black sand, mud	dredge, beam trawl	—	—	36-84 ft. 90-120 ft.
161	A-134 (NMC61-131)	11 July	reef, middle Resurrection B.	60° 2′ 149° 23′	rock	jigging	—	—	90-150 ft.
162	A-135	11 July	head Thumb B., Resurrection B.	60° 1′ 149° 20′	glacial mud and debris	Ekman dredge	—	—	72 ft.
163	A-136 (NMC61-132)	12 July	head Thumb B., Resurrection B.	60° 0′ 149° 17′	gravel, sand, mud eelgrass	seine and dip-net	12.2	20.7	LW
164	A-137 (NMC61-133)	12 July	Seward	60° 7′ 149° 26′	brackish lagoon, grass	seine and dip-net	8.0	1.2	MW
164a	(NMC61-134)	spring	Rugged I. s. Resurrection B.	*ca.* 59° 51′ *ca.* 149° 23′	rock-fish stomach	—	—	—	—

STATION LIST—*Cont.*

Map Sta.	Station	Date	Locality	Latitude and Longitude	Habitat	Collecting Methods	Temp.°C	Sal'y. ‰	Depth
164b	(NMC61-135)	12 April	Stream w. Seward Airport.	60° 7′ 149° 29′	tidal stream	minnow trap	—	—	—
165	A-138 (NMC61-136)	12 July	n. side MacLeod Harbour, Montague I.	59° 53′ 147° 46′	mud, detritus, eelgrass	jigging, Ekman	10.5	—	30 ft.
166	A-139 (NMC61-137)	13 July	n. shore MacLeod Harbour, Montague I.	59° 53′ 147° 46′	sand, gravel, stones, eelgrass, *Laminaria*	seine and dip-net	11.4	27.7	LW
167	A-140 (NMC61-137A)	13 July	s. side MacLeod Harbour, Montague I.	59° 52′ 147° 46′	fine sand, eelgrass	dip-net	—	—	LW to HW
168	A-141 (NMC61-137B)	13 July	Hanning B., Montague I.	59° 58′ 147° 42′	muddy sand	anchor, Ekman	—	—	65 ft.
169	A-142 (NMC61-138)	13 July	The Needles, Montague Str.	60° 7′ 147° 36′	rock	jigging	—	—	60–70 ft.
170	A-143 (NMC61-139)	13 July	2 mi. n.e. of The Needles, Montague Str.	60° 9′ 147° 31′	mud	beam trawl	—	—	378–396 ft.
171	A-144 (NMC61-140)	13 July	2 mi. s.e. of Green I., Montague I.	60° 11′ 147° 26′	sand, crinoids	beam trawl	—	—	192–312 ft.
172	A-145	13 July	s.w. end Port Chalmers, Montague I.	60° 13′ 147° 17′	mud and detritus	Ekman	—	—	40 ft.

73	A-146 (NMC61-141)	14 July	s. of Port Chalmers, Montague I.	60° 13′ 147° 17′	mud, gravel flats, eelgrass	shovel and seine	13.1	28.7	LW to MW
174	A-147 (NMC61-142)	14 July	island at pt. 2½ mi. s.w. of Pt. Gilmour. Montague I.	60° 13′ 147° 17′	rock, algae, boulders, tidepools	dip-net	13.4	—	LW to HW
175	A-148 (NMC61-143)	14 July	off n. end Montague I.	60° 22′ 147° 11′	mud, some sand	beam trawl	—	—	222-246 ft.
176	A-149 (NMC61-144)	14 July	3 mi. n.e. by e. of Johnstone Pt., Hinchinbrook I.	60° 30′ 146° 29′	grey mud	beam trawl	—	—	216–228 ft.
177	A-150 (NMC61-145)	14 July	bay 3¾ mi. e. Johnstone Pt.	60° 28′ 146° 29′	gravel, mud, shells	jigging, Ekman, anchor	—	—	33 ft.
178	A-151 (NMC61-146)	15 July	islet 4¼ mi. e. Johnstone Pt.	60° 28′ 146° 28′	bed-rock, boulders, mud, sand, eelgrass	dip-net and seine	13.4	28.3	LW to HW
178a	(NMC 61-147)	3 Nov. 1959	Tween Green I., Stockdale Harbour, Montague Str.	60° 18′ 147° 17′	mud	otter trawl	6.6	—	360-372 ft.
179	A-152	15 July	pond 4¼ mi. e. Johnstone Pt.	60° 28′ 146° 28′	pond	dip-net and seine	—	—	2 ft.
180	A-153 (NMC61-148)	16 July	e. end of Mummy I.	60° 28′ 145° 59′	rock, mud, sand, tidepools	seine and dip-net	11.4	28.4	LW to HW
181	A-154	16 July	Egg I.	60° 20′ 145° 44′	sand	dip-net	14.0	—	HW drift
182	A-155 (NMC61-149)	17 July	Okalee Spit, opp. Kayak I.	60° 2′ 144° 14′	sand	hand and seine	12.2	—	MW to HW and drift
183	A-156	21 July	off mouth Dangerous R.	59° 17′ 139° 12′	pelagic	dip-net	—	—	surface

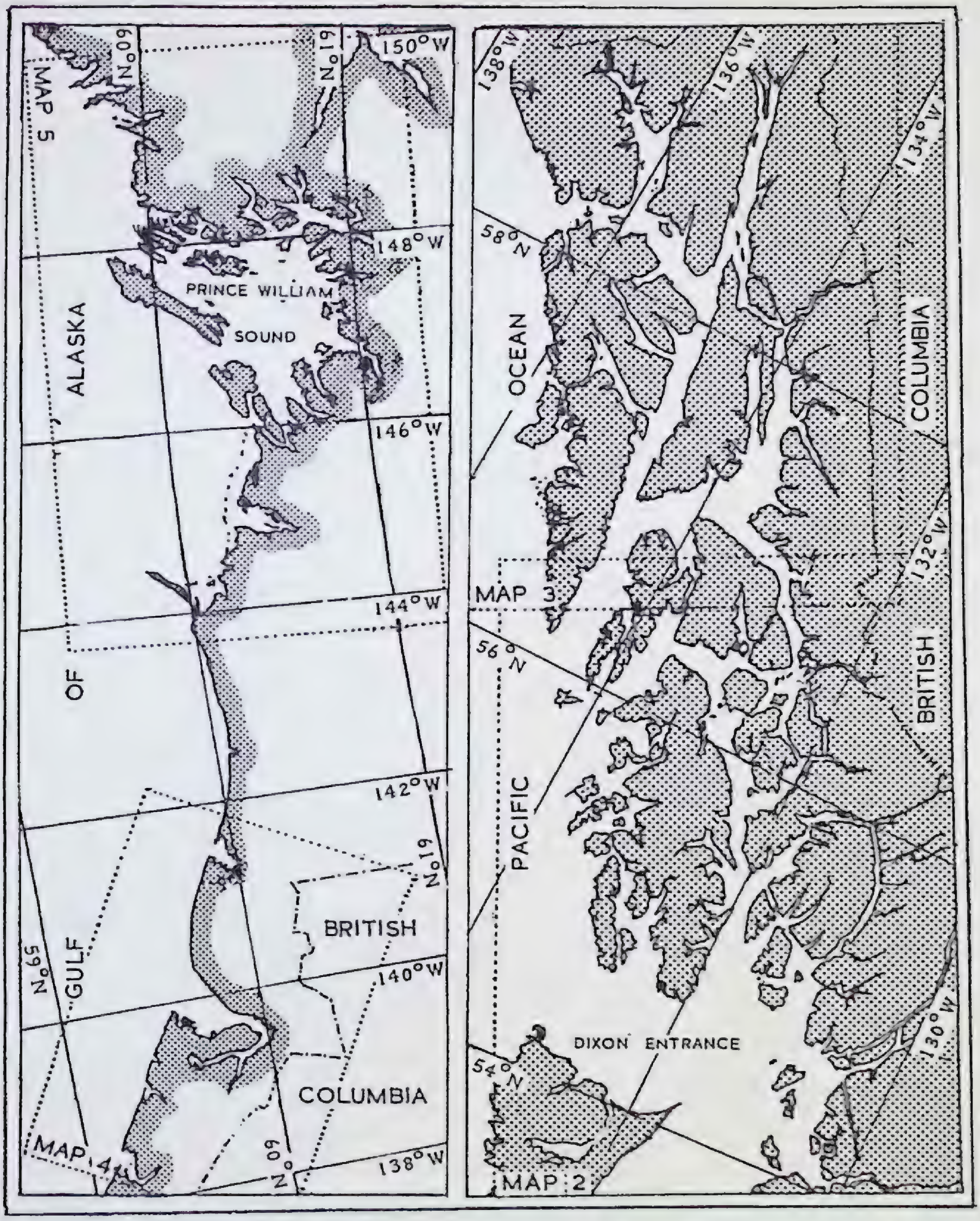
STATION LIST—*Cont.*

Map Sta.	Station	Date	Locality	Latitude and Longitude	Habitat	Collecting Methods	Temp.°C	Sal'y. ‰	Depth
184	A-157	22 July	Cape Spencer, Cross Sd.	58° 11′ 136° 35′	pelagic	temp. and sal. sta.	9.3	31.6	surface
185	A-158	22 July	entrance to Lisianski Inlet, Cross Sd.	58° 7′ 136° 26′	pelagic	temp. and sal. sta.	10.7	31.2	surface
186	A-159 (NMC61-150 NMC61-151)	22 July	Yakobi I., Lisianski Str.	57° 57′ 135° 23′	gravel, coarse sand flats, tidepool	dip-net	12.0	—	LW to HW
187	A-160	22 July	Yakobi I., Lisianski Str.	57° 57′ 135° 23′	etrrestrial under logs and moss	hand	—	—	4–6 ft. alt.
188	A-161 (NMC61-152)	22 July	entrance to Portlock Harbour, Hill I.	57° 44′ 136° 16′	rock	jigging	—	—	36 ft.
189	A-162	22 July	mouth Portlock Harbour, Hill I.	57° 44′ 136° 16′	rock, tidepool	dip-net	—	—	HW
190	A-163 (NMC61-152A)	22–23 July	islet n. Imperial Passage, Hill I.	57° 44′ 136° 16′	rock	gill-net	—	—	10–30 ft.
191	A-164 (NMC61-153)	23 July	n.w. side Hogan I., Imperial Passage	57° 43′ 136° 16′	rock, tidepools, gravel, boulders	dip-net and seine	12.5	22.5	LW to HW
192	NMC61-154	23 July	head Leo Anchorage, Khaz Pen., Chichagof I.	57° 25′ 135° 51′	gravel, boulders, kelp	jigging	—	—	20–40 ft.
193	A-165	23 July	head Leo Anchorage, Khaz Pen., Chichagof I.	57° 25′ 135° 51′	mud and shell	dredge	—	—	120–150 ft.

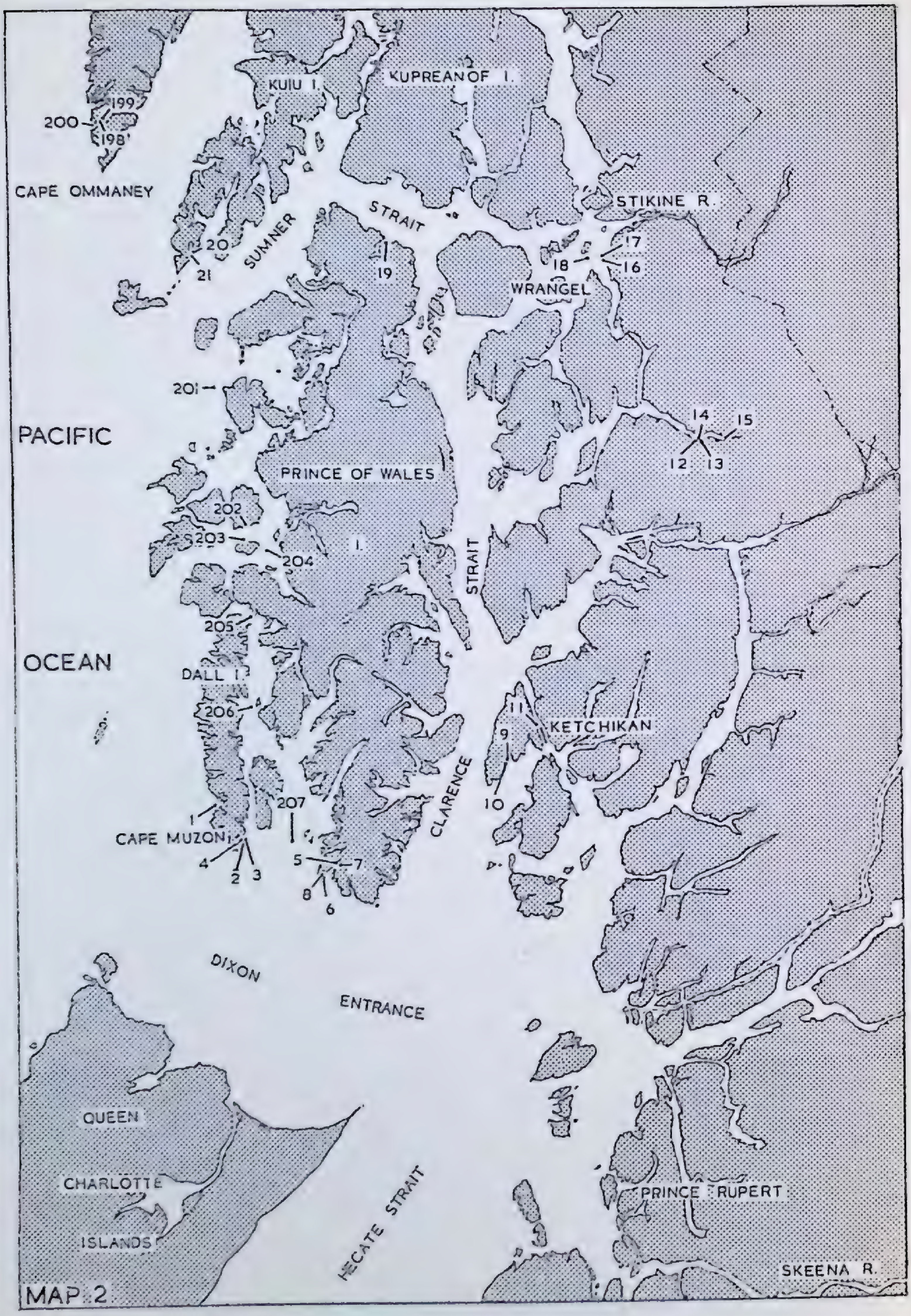
194	A-166 (NMC61-155)	23 July	stream and lake at head Leo Anchorage	57° 25′ 135° 51′	boulders, stones, detritus	seine and dip-net	warm	fresh	*ca.* 5 ft. alt.
195	A-167 (NMC61-156)	24 July	Leo Anchorage, Chichagof I.	57° 25′ 135°52′	mud anddead animals	beam trawl	—	—	150–198 ft.
196	A-168 (NMC61-157)	24 July	Klokachef I., Chichagof I.	57° 25′ 135° 52′	boulders, kelp	dip-net	12.0	30.9	LW
197	A-169 (NMC61-158)	24 July	Bjorka Channel 1 mi. n. Tava I.	56° 16′ 135° 30′	rock	jigging	—	—	180 ft.
198	A-170 (NMC61-159)	24–25 July	Puffin B., Baranof I.	56° 16′ 134° 48′	rock, coral, shells	gill-net	—	—	240 ft.
199	A-171 (NMC61-160)	25 July	Puffin B., Baranof I.	56° 16′ 134° 48′	rock, boulders, algae	dip-net	10.5	31.9	LW to HW
200	A-172	25 July	small island, mouth Puffin B.	56° 15′ 134° 37′	vertical rock face	hand	—	—	LW to MW
201	A-173 (NMC61-161)	25 July	e. of Losa I., w. of Hecata I.	55° 46′ 133° 45′	rock	jigging	—	—	90-220 ft.
202	A-174 (NMC61-162)	26 July	cove w. Pt. Cuerbo, San Fernando I.	55° 29′ 133° 19′	sand, gravel, eelgrass	seine and dip-net	12.5	30.7	LW
203	A-175 (NMC61-163)	26 July	w. Pt. Eugenia, San Juan Batista I.	55° 26′ 133° 18′	sand, rock, tidepools, eelgrass, algae	seine and dip-net	14.5	30.8	LW to HW
204	A-176 (NMC61-164)	26 July	between Coronados and San Juan Batista I.	55° 25′ 133° 11′	sand, gravel	beam trawl	—	—	318–384 ft.
205	A-177	26 July	Tlevak Narrows, Dall I.	55° 16′ 133° 8′	pelagic	dip-net	—	—	surface

STATION LIST—*Conc.*

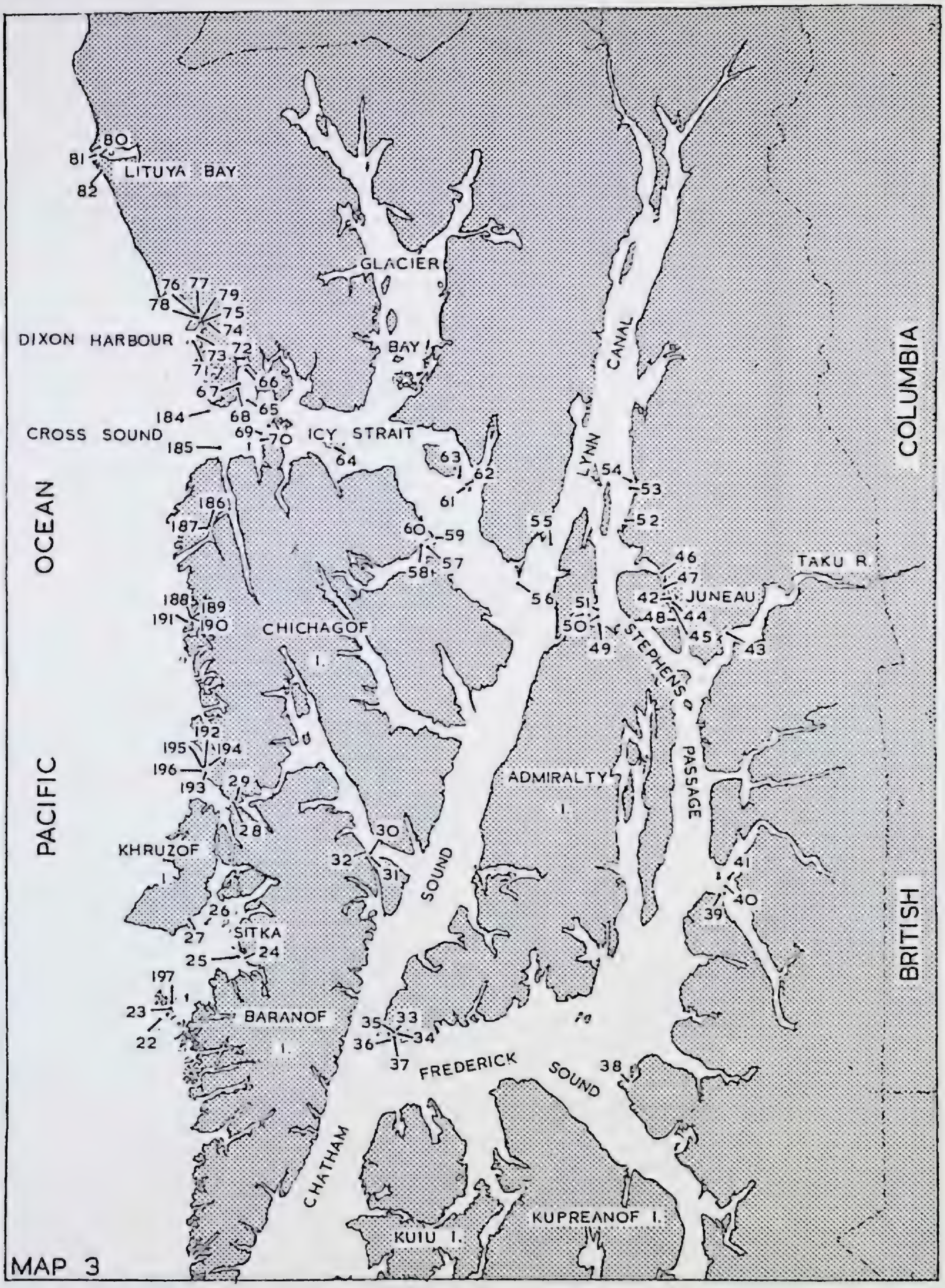
Map Sta.	Station	Date	Locality	Latitude and Longitude	Habitat	Collecting Methods	Temp. °C	Sal'y.‰	Depth
206	A-178	26 July	Tlevak Str.	55° 9′ 133° 0′	rock	jigging	—	—	78 ft.
207	A-179 (NMC61-165)	26 July	Dewey Rocks, n.w. Pt. Marsh, Prince of Wales I.	54° 44′ 132° 29′	rock	jigging	—	—	120-180 ft.



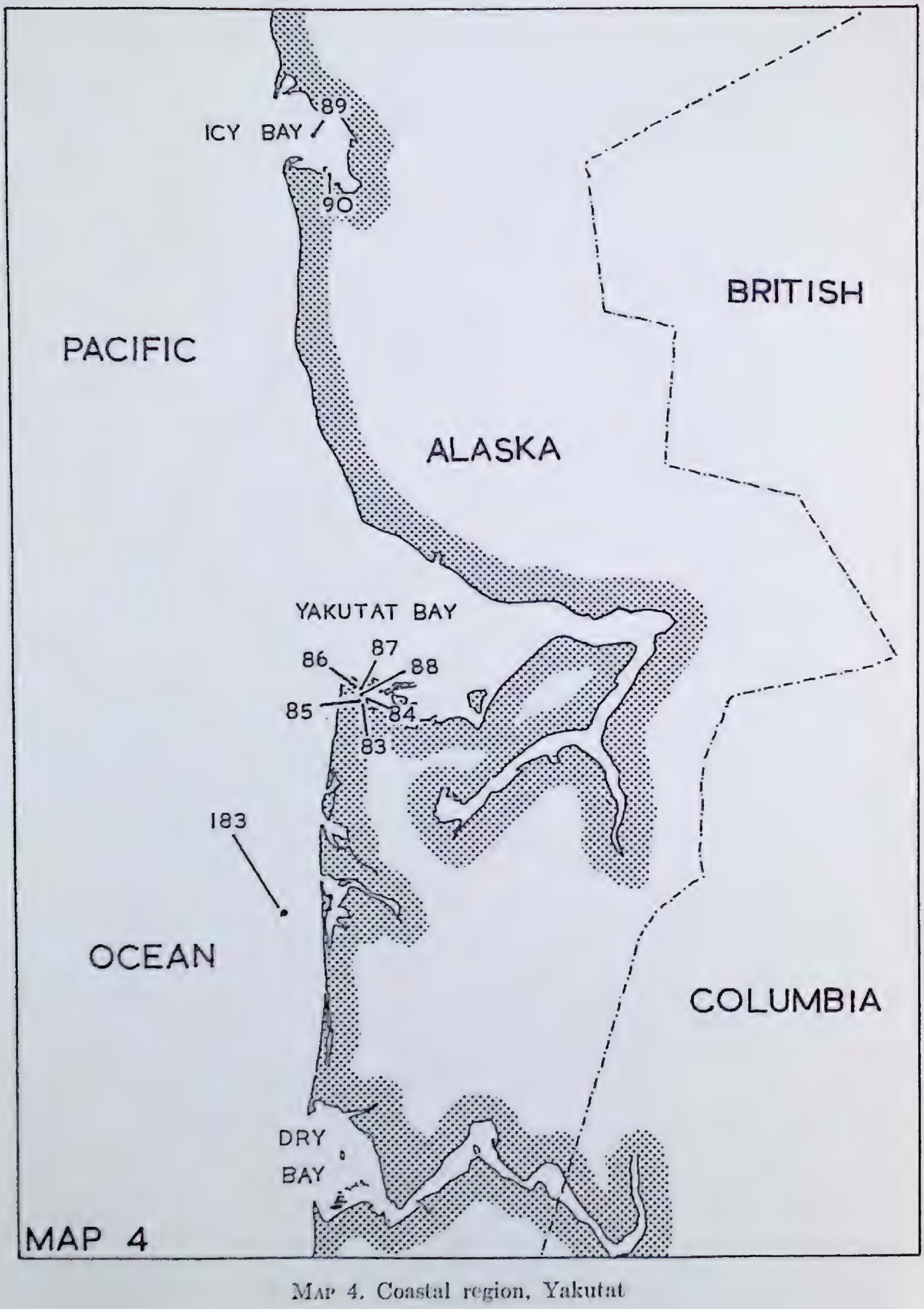
Map 1. Coastline of southeastern Alaska and Prince William Sound



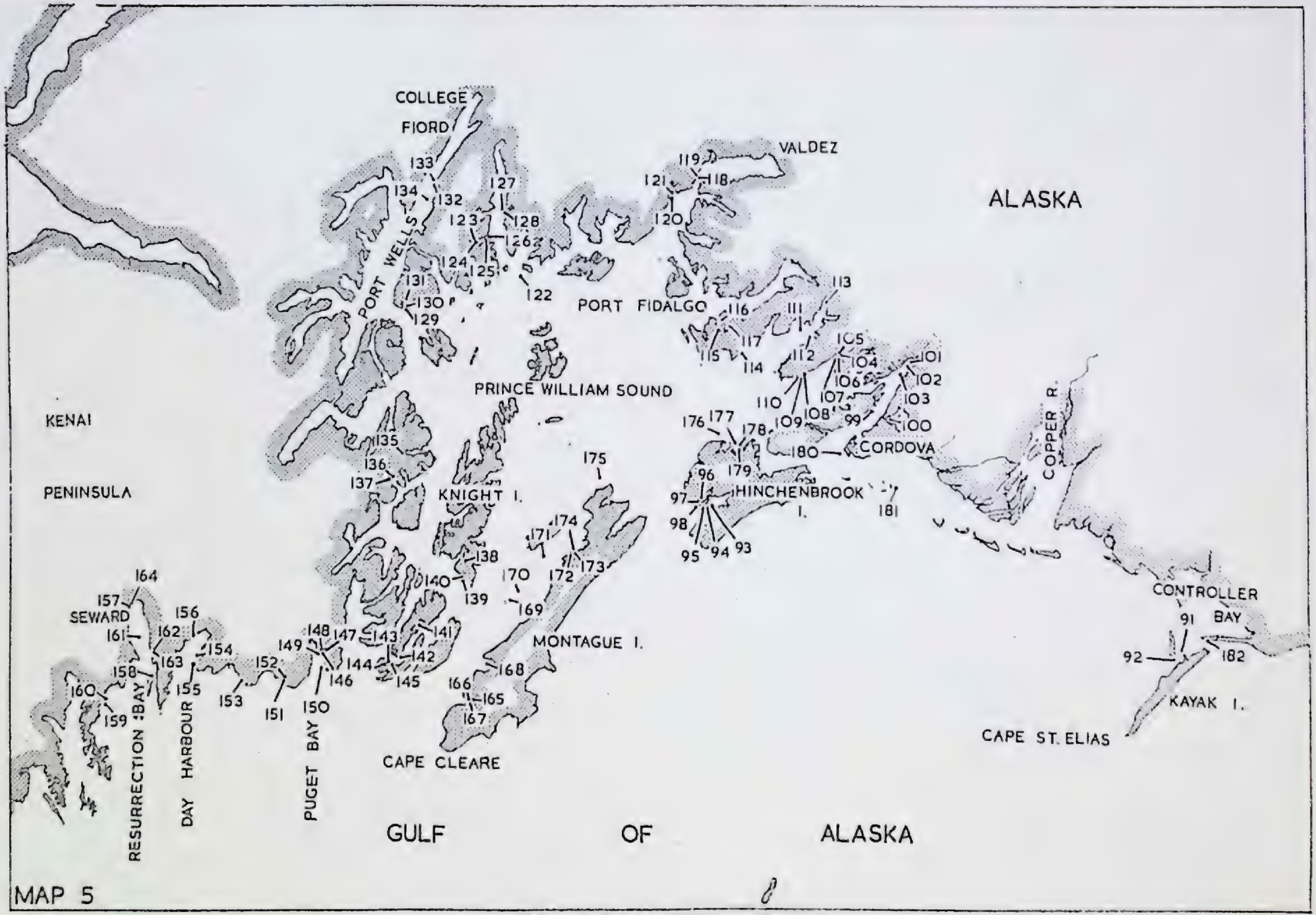
Map 2. Coastal region, Ketchikan – Wrangell



Map 3. Coastal region, Sitka – Juneau



Map 4. Coastal region, Yakutat



Map 5. Prince William Sound

DISPERSAL OF THE INTRODUCED GREEN FROG IN NEWFOUNDLAND

By Austin W. Cameron and A. J. Tomlinson

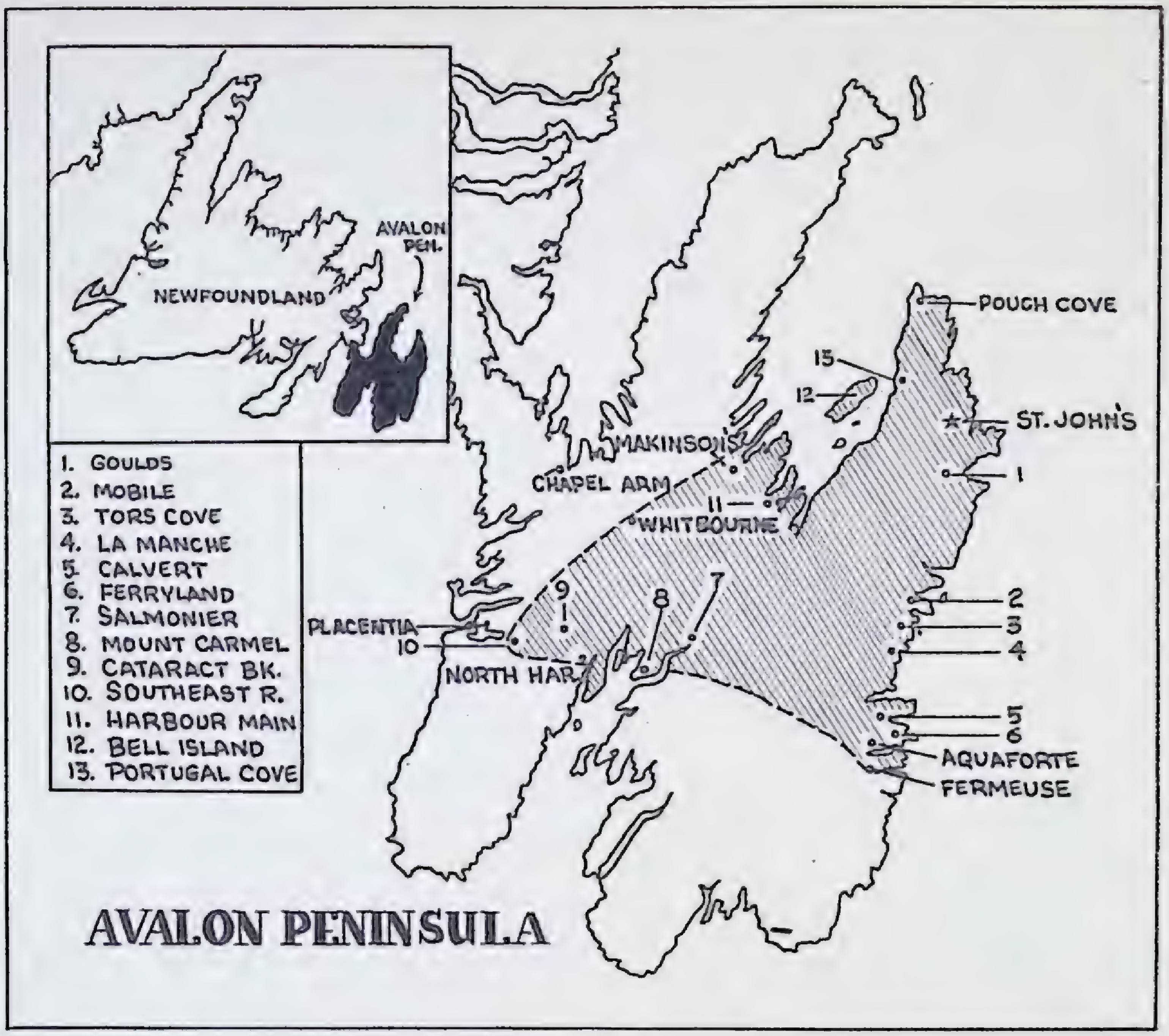
Newfoundland has no native reptiles or amphibians, and the only representative of the latter group occurring on the Island is the Green Frog (*Rana clamitans*), which was introduced to the Avalon Peninsula about a century ago. Apart from brief references to this introduction, there have been no published reports on the status of the frog in Newfoundland, nor has any attempt been made to determine the extent of its dispersal from the original site of introduction.

In an attempt to obtain first-hand information on the subject, Cameron spent the period June 17 to July 8, 1960, on the Avalon Peninsula collecting specimens and mapping the present range of the population. He found that the problem was too complex to be adequately studied in such a brief period, and Tomlinson resumed the project in 1961 when he spent a month, from August 18 to September 19, carrying out field work in the areas not covered by Cameron. The latter, in addition, spent the period August 23 to 28, 1961, in southeastern Newfoundland examining areas where frogs were reported to have been introduced. The results of these studies form the subject of the present paper.

Unfortunately there is no record of the exact date of the introduction nor of the locality in which the frogs were released. The first published record of their occurrence seems to be that of E. Maret, in a paper published by the Nova Scotia Institute of Science, 1867, in which he states "I find that frogs do exist in Newfoundland and several colonies of them inhabit the ponds and lakes about St. John's (but) at all events they are not numerous." It would appear, therefore, that the introduction was made near St. John's some time prior to 1867; probably not many years before, however.

The next published report of any consequence appears to be that of Johansen (1926) who found frogs quite common in 1922 in the ponds and lakes near St. John's. He quotes Arthur English (formerly Director of the Newfoundland Provincial Museum), who believed that the frogs had been brought from Nova Scotia in shipments of hay less than a century prior to Johansen's visit. English informed him that they were not commonly seen, however, until about 1895. Johansen points out that this frog was confined to the Avalon Peninsula in 1922.

Statements in non-technical publications bearing on the occurrence of the Green Frog in Newfoundland leave the reader with the impression that this species occurs commonly throughout the entire Avalon Peninsula. We found, however, that despite a period of almost a century in which to disperse and an absence of any competition, this species has spread over less than half of the Peninsula (*see* Map). In fact, it appears that there has been little, if any, natural spread much beyond 70 linear miles in any direction from the original site of introduction, or an average of only seven miles per decade.



Map Fig. 1. Distribution of the Green Frog in Newfoundland

In addition to the population that occurs on the Avalon Peninsula, which appears to be derived without human intervention from the original introduction, there are smaller populations scattered throughout other parts of Newfoundland. The Executive Commissioner of the Provincial Boy Scouts Association informed Cameron that many of these populations are derived from frogs collected on the Avalon by Boy Scouts and shipped to points elsewhere on the Island. One such population occurs at Eastport in Bonavista Bay, where Hubert J. Squires of the Newfoundland Biological Station collected five specimens on June 22, 1960. Leslie M. Tuck of the Canadian Wildlife Service told us that frogs now occur at Port-aux-Basques, at the southwest corner of the Province, and at Port Saunders, 40 miles south of the Strait of Belle Isle.

Dr. W. B. Scott and Dr. E. J. Crossman of the Royal Ontario Museum collected and made observations on Green Frogs while engaged in a study of the freshwater fishes of Newfoundland during the summer of 1960. Outside the Avalon Peninsula they observed this species at Springdale in Notre Dame Bay and heard them singing at Rushy Pond, near Grand

Falls. The Springdale population is said to have been brought from the Burin Peninsula where they were introduced about 1940.

Tomlinson received reports of their occurrence at Glovertown and Traytown, communities which lie just west of Eastport, Bonavista Bay. Small populations were also reported from Angle Brook (Terra Nova River area) and Cobbs Pond (near Gander).

Mr. Allister Flemming of the Newfoundland Biological Station secured data on frog distribution while carrying out a study of the marine fishes in a number of coastal areas. The following are areas outside the Avalon Peninsula where they are present:

Creston, Burin Peninsula (present for many years)
Clarenville, Trinity Bay
Bonavista, Bonavista Bay
Fogo, Fogo Island
Seldom-Come-By, Fogo Island
Springdale, Notre Dame Bay

Logier and Toner (1961) record this species at Glovertown.

Frogs were reported by Flemming as being absent from the following localities outside the Avalon Peninsula:

Little Hearts Ease, Trinity Bay
Musgravetown
Trinity Harbour
Twillingate (but being introduced in small numbers)
Fortune Harbour, Notre Dame Bay
Pilley's Island, Notre Dame Bay

The distributional pattern on the Avalon Peninsula is of considerably more interest because it appears that in this area there have been few, if any, transplants by man apart from the original introduction. The following is a resumé of observations made on this Peninsula:

Frogs are common in the vicinity of St. John's and occur northward to Pouch Cove where Tomlinson collected three specimens on August 21, 1961, in a pond approximately one mile north of this community. They also occur on Bell Island where they were introduced by a Reverend Oliver Jackson (Ayre, 1938). On the peninsula dividing Conception and Trinity bays, ponds and lakes were examined as far north as Carbonear and Freshwater, but no definite indications of frogs could be found north of Makinsons, which is about six miles southwest of Clark's Beach. Local residents, however, reported them inland from Bay Roberts, a locality 7 miles north of Clark's Beach. Thus it appears that frogs have scarcely invaded this peninsula.

Dispersal in a northwesterly direction appears to have extended only as far as Whitbourne. Tomlinson made an intensive study of the area along the Trans-Canada Highway from Whitbourne to Chapel Arm but could find no evidence of frogs. He was told that they had been seen at Chapel Arm, and he made a careful search along the Chapel Arm River for approximately two miles with negative results. Scott and Crossman also made observations along the Whitbourne-Chapel Arm highway, again with negative results. Frogs are absent from the Long Harbour, Placentia Bay, area, according to Edward Bruce, and a similar report came from Thomas O'Keefe of Placentia with regard to their occurrence in his area.

Scott and Crossman collected frogs on the Southeast River, 6 air-miles east of Placentia, at Cataract Brook about midway between Cape Verde and Colinet and at North Harbour in St. Mary's Bay. These appear to be the most southwesterly records for the Avalon.

Mr. Flemming reports that frogs occur at North Harbour and Mount Carmel at the head of St. Mary's Bay and also at Harbour Main at the head of Conception Bay. Apparently none occur at Carbonear or Freshwater in Conception Bay, at Long Cove or Hant's Harbour in Trinity Bay, or at Fairhaven on the western shore of the isthmus connecting the Avalon Peninsula with the mainland of Newfoundland, according to reports received by Tomlinson.

Scott and Crossman examined the area on the isthmus of the Avalon locally known as the "Doe Hills" and concluded that this range of hills could constitute an effective dispersal barrier for frogs. Examination of a large-scale topographical map of the area reveals that a high range of hills extends from Little Chance Cove and Ranten Cove in Trinity Bay westward to Upshall, Little Harbour, and Pumbly Cove, in Placentia Bay. There are fewer ponds here than elsewhere, and many of them are small and isolated on tops of higher hills. Only one brook connects the watersheds on either side of this range of hills, and there are apparently few bogs in the area. If the frogs should spread westward, it is highly probable that this range of hills will seriously hamper further dispersal.

Moving southward from St. John's along what is locally known as the "Southern Shore", Cameron found frogs common, sometimes abundant, as far as Ferryland, which is slightly more than two-thirds of the distance from the northern to the southern tip of the eastern extension of the Avalon.

This amphibian was found to be quite common at Mobile and Tor's Cove, and not uncommon on the Mount Carmel Road (15 miles inland from Cape Broyle), at La Manche, Calvert, and Ferryland. A few were seen, and one was collected at Fermeuse, the southernmost point at which frogs were observed. They apparently have not spread southward beyond this point, although many of the lakes and ponds at the southern tip of the peninsula appear as suitable for them as those north of Fermeuse.

All suitable areas were examined along the highway from Renews to Portugal Cove South and Trepassey, which is at the very southern tip of the peninsula, without finding any evidence for their occurrence. Local residents confirmed these findings, stating that frogs do not occur south of Fermeuse. This is of interest because several heavily vegetated shallow ponds near Portugal Cove South appeared more favourable for this species than any seen elsewhere on the Avalon.

What is of particular interest in the distributional pattern on the Southern Shore is that the frogs should occur abundantly in almost all the localities southward from St. John's and then cease abruptly at Fermeuse. Had they extended their range south to Cappahayden, however, it is probable that the extensive barrens between that locality and Portugal Cove South would have prevented their spread to the southern tip of the peninsula.

A closer examination of the area between Fermeuse and Renews was then made in an effort to determine what factor or factors have restricted the frogs in their dispersal southward. In addition, large scale topographical maps of the area were examined in detail.

Along the entire Southern Shore, long narrow bays extend inland, continuing westward as rather steep-sided valleys, each with its own watershed. Most of the drainage areas are more or less connected with adjacent ones by ponds and lakes, thus making it possible for frogs to spread from one to the other. For example, the drainage systems of the Fermeuse and Aquaforte valleys are connected by ponds 3 miles inland from the brook estuaries. The watersheds of Cape Broyle and Tor's Cove Pond join 5 miles inland from the heads of the bays, as well as being more or less connected by bogs and marshes nearer to the coast.

By contrast, the drainage systems of the Fermeuse and Renews are separated by a range of hills varying in height from 350 feet near the coast to 650 feet 15 miles inland. From the maps it appears that the top of this range of hills is quite dry, and 2 miles seems to be the shortest distance between watered areas in the two systems.

This high, relatively dry range of hills, therefore, may be the barrier that has limited the frogs in their spread southward, but the evidence is by no means conclusive.

Green Frogs are not uniformly distributed throughout the watered areas within their dispersal range on the Avalon Peninsula. We examined many apparently suitable ponds where none could be found, but other less attractive looking habitat often had reasonably high populations. Brook trout (*Salvelinus fontinalis*) occur widely in brooks and ponds in Newfoundland, and in all cases where these fish were found to occur, no frogs were seen, although the habitat appeared quite suitable for them. The absence of the frogs may be due, in part, to the fact that trout feed on small tadpoles (Crossman, pers. comm.). In general, however, the watered areas particularly favourable to the trout were not suitable for frogs.

In almost all cases, frogs were found in shallow ponds or slow-moving brooks which were in sheltered areas with trees or vigorous herbaceous growth around the edges, and considerable aquatic plant growth. As it is true on the mainland, clear rocky lakes in exposed areas were not frequented by the frogs.

On June 19, 1960, several egg masses were collected by Cameron near Holyrood, and tadpoles that had overwintered were seen July 2 by him on the Mount Carmel Road (2 miles inland from Cape Broyle). Tomlinson collected a tailed tadpole 93 mm in length and an almost completely metamorphosed specimen, 34 mm in length, at Pouch Cove on August 21, 1961. Adult specimens were collected at Makinsons, Holyrood, Pouch Cove, Goulds, Renews, and Fermeuse.

DISCUSSION

The fate of species deliberately or accidentally introduced into areas where they do not ordinarily occur but where they presumably should find conditions suitable is of considerable interest to the ecologist and the conservationist. In a large percentage of the cases, the introduction is a failure; occasionally it is successful; and in a few unfortunate cases it is too successful (Elton, 1958). The reason for the success or failure of an introduced species to adapt to a new environment is often not too apparent to the biologist, even in those cases where the requirements of the species are thought to be reasonably well understood, and the area into which they were introduced was carefully studied before the transplant was made. Obviously in these cases there are ecological factors that have been overlooked or the requirements of the species have not been so well understood, as was supposed. Attempts to analyse specific cases are often hampered by the fact that the species dies out before a study can be completed or, in the case of successful transplants, the environmental factors are so complex that it is difficult to isolate those that are critical for the survival of the species from those that are of minor importance or are strictly neutral.

The critical factors for a given introduced species can best be ascertained in those cases where the population has survived in the environment for many generations but where its numbers have been seriously limited by ecological or other factors. This is particularly true if there are no closely-related competitive species occupying the same range and where other environmental factors are relatively simple. The Green Frog in Newfoundland fulfils both requirements remarkably well, and it therefore seemed particularly desirable to give the problem some attention.

It should be pointed out that the absence of reptiles and amphibians on the Island, as well as many small species of mammals, is due not to unsuitable environmental conditions but rather to the fact that there has not been a post-glacial land bridge connecting Newfoundland with the neighbouring mainland by which these animals could have reached the Island (Cameron, 1958). Bleakney (1958) expresses similar views in his discussion on the distribution of reptiles and amphibians in Eastern Canada. There are, in fact, a number of northern species of amphibians, such as the Wood Frog (*Rana sylvatica*), which would undoubtedly spread over most of the forested parts of the Island were they introduced.

Though we cannot claim to have discovered why frogs are so limited in their distribution, a few significant facts appear to have emerged from this study. Obviously there are delimiting factors of some importance, otherwise the population density would have reached a higher level, and there would have been more widespread dispersal in the hundred years since the introduction was made. Physical barriers do exist in one or two instances, but these do not appear to be significant when the dispersal pattern, as a whole, is considered. It is much more probable that certain ecological factors, such as scarcity of suitable habitat or low temperatures during the breeding seasons, are the chief delimiting factors. Lack of suitable habitat may indeed be a factor because, although there are many ponds and other watered areas on the Avalon, most of them are unvegetated glacial depressions or are situated in bogs, neither of which is particularly favourable to the Green Frog. The temperature during the breeding season may also be a factor, as the springs in eastern Newfoundland are characterized by low temperatures, and egg-laying in this species does not regularly occur until the temperature reaches 75°F or thereabouts (Pope, 1944). Furthermore, in northern areas tadpoles of this species often do not metamorphose until their second summer, which would tend to retard population growth. Perhaps the fact that Green Frogs tend to be sedentary may also be a factor in their slow spread into unoccupied territory.

Only further study will reveal to what extent predation plays a role in keeping their numbers down. It is known that brook trout (*Salvelinus fontinalis*) feed on young tadpoles, and since this fish is common and widespread throughout the watered areas on the Avalon, their depredations may be significant.

To summarize, the Green Frog in Newfoundland is apparently living in a marginal area, ecologically speaking, because the population density is low and the dispersal range is restricted, despite the fact that the species was introduced almost a century ago. Dispersal is thought to be slow because there is not sufficient population pressure to force the species into unoccupied territory.

Acknowledgments

Thanks are due to the following for assistance in carrying out this project: Hubert J. Squires and Allister M. Flemming of the Newfoundland Biological Station, St. John's; Leslie M. Tuck, Canadian Wildlife Service, St. John's; Dr. W. B. Scott and Dr. E. J. Crossman, Royal Ontario Museum, Toronto; Edward Bruce of Long Harbour and Thomas O'Keefe of Placentia, Newfoundland. Thanks are also due to Arthur A. MacKay for preparing the map.

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BREEDING PLACES OF THE IVORY GULL IN ARCTIC CANADA

By S. D. MacDonald[1] and A. H. Macpherson[2]

LITERATURE REVIEW

Although no breeding specimens of the Ivory Gull (*Pagophila eburnea*) have been collected in Arctic Canada, there are a number of records which indicate that the species occupies an extensive breeding range, chiefly on the arctic islands. We have recently had occasion to examine some of the records, a task complicated by the fact that standard authorities tend to omit references to the original reports from which the breeding range of each species has been compiled.

The A.O.U. Check-list (1957, p. 229) gives Prince Patrick Island, Melville Island, and northern Baffin Island as breeding localities. Bent (1947, p. 35) summarizes the breeding range in Canada as follows, "Known breeding places: Prince Patrick Island, Melville Island (Winter Harbour), northern Baffin Land (Port Bowen) ... also said to have bred at Darnley Bay . . . ." Witherby *et al.* (1944, vol. 5, p. 121) say that the species breeds on "Polynia, Prince Patrick and Melville Is., and from Ellesmere Is. and N. Greenland to N. Baffin Is." Snyder (1957, p. 215) shows the breeding range of the species in Canada on a map as follows: the whole of Prince Patrick Island, the eastern quarter of Melville Island, the northwest coast of Brodeur Peninsula (Baffin Island), and an area in central-eastern Ellesmere Island.

The presumed breeding range of the Ivory Gull, as described by the authorities quoted, thus extends over a considerable part of Arctic Canada. Places definitely mentioned are the Polynia Islands and Prince Patrick Island, eastern Melville Island, particularly Winter Harbour, northern Baffin Island, central east Ellesmere Island, and Darnley Bay on the coast of the Beaufort Sea. Ivory Gulls have also been reported breeding at Cape Parry (Swainson and Richardson, 1831, p. 419) and near Meighen Island (Stefansson, 1921, p. 522). On June 18, 1916, at 80° 05′N., 102°W. (near Meighen Island), Stefansson found on "a reef" two nest depressions and one completed nest containing two eggs, which he collected and presented to the American Museum of Natural History. According to A. C. Bent, L. B. Bishop, and P. A. Taverner, these eggs are well within the measurements given for eggs of the Ivory Gull (Taverner, unpub. MS.).

The breeding records for the Polynia Island and Prince Patrick Island were made by M'Clintock in 1853 (M'Clintock, 1857, p. 229; ibid., 1856, p. 42; ibid., 1855, pp. 572, 587; *see also* Carte, 1856, p. 59; and Wright, 1866, pp. 216–18). On Polynia Islands he collected an egg which he presented to the Dublin Natural History Museum. In an illustra-

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[1] National Museum of Canada.

[2] Canadian Wildlife Service, Ottawa.

PLATE I

Courtesy, G. Schibye

A. June 25, 1960. Two Ivory Gulls at their nests in the colony on the rock-covered floating ice island.

Courtesy, G. Schibye

B. June 25, 1960. Nest and eggs of Ivory Gull on ice island. Note shallow nest scrape in the rock debris and absence of nest material.

tion (Carte, 1856) it measures 63.4 mm by 42.0 mm. If the illustration of this egg is natural size, it would appear to be within the range of Ivory Gull egg measurements given by Bent (1947, p. 32). One occupied and two unoccupied nests were found by M'Clintock on gravel beaches.

Much of southeastern Prince Patrick Island was examined for birds in 1949, 1952, and 1954, but no Ivory Gulls were observed during the surveys (MacDonald, 1954; Macpherson, field notes).

Dr. R. Thorsteinsson of the Geological Survey of Canada was on the watch for the species on his visit to Meighen Island in 1957. However, he saw no Ivory Gulls there between May 30 and June 5, 1957, although one was seen flying toward it a few miles away on the latter date (Thorsteinsson, 1961, p. 18).

The only record of the Ivory Gull that we have been able to find for Melville Island is not a breeding record; furthermore it is contradicted. Fisher (1821, p. 195) saw two Ivory Gulls at Winter Harbour on May 27, 1820. Later (p. 234) he says, "Brent Geese, king ducks, and long-tailed ducks, arctic and glaucous gulls, comprised the whole of the aquatic birds that we saw . . . ." "Arctic gulls" are previously (p. 217) identified as follows: "four arctic gulls (*Larii Parasitici*)," and they are therefore undoubtedly Parasitic Jaegers and not Ivory Gulls. The naturalist of the expedition, Sabine, merely says of the Ivory Gull (1824, p. ccv) that it was rarely seen in the Polar Sea. We have found no other references to the Ivory Gull on Melville Island than these.

James Clark Ross (1835, p. xxxv) says, "Although extremely numerous in Baffin's Bay, and frequently met with during our former voyages in the vicinity of Port Bowen, one of its breeding-places, yet few were seen by us after passing to the southward of that part of Prince Regent's Inlet; and only one specimen was obtained." Ross had accompanied two voyages to the vicinity of Port Bowen. The first, Parry's first voyage in search of a northwest passage (Parry, 1821; Fisher, 1821; Sabine, 1824), apparently recorded no Ivory Gulls at Port Bowen; Sabine's remark at the conclusion of the voyage, that it was rarely seen in the Polar Sea, has been mentioned above. The second, Parry's third voyage, occasionally recorded Ivory Gulls—at Port Bowen; in the country to the east; and near Cape York; all in 1824 (Parry, 1826, pp. 81, 82, 84). The next year Lt. Hooper remarked in his diary for July that a few Ivory Gulls had nested near by; his journal and that of Midshipman Westropp, preserved in the Library of the Royal Geographical Society, contain several other mentions of the Ivory Gull. Had Ross corroborated the breeding record at the time, we would have little doubt that the species did breed there in 1824–25, but in his zoological appendix to the narrative of the voyage (1826, p. 104), he merely says that the species was "very numerous in Davis Strait and Baffin's Bay." We must therefore consider the breeding of the species at Port Bowen as questionable and Ross's statement of 1835 indefinite.

Bray (1943, p. 529) says, "Iktukshakdjuk, the 'Old King,' told me that many years ago he found enormous numbers nesting in the interior of Brodeur Peninsula and on the cliffs of Prince Regent Inlet (Port Bowen region). He had been nearly starving, and lived for some time on the eggs." Ellis (1956, p. 220) heard a similar account, presumably at Arctic Bay. He says, "This species the [Ivory Gull] . . . was reported to nest in such large numbers in the interior of Brodeur Peninsula that the ground in summer is coloured white from the faeces of the birds as though the land has a permanent covering of snow." D. F. Parmelee tells us that he heard a similar story from an Eskimo at Cambridge Bay in 1960. Thus, although there are no definite breeding records from Brodeur Peninsula, there is strong evidence that the species does nest there.

We have found only one breeding record for the Ivory Gull on east Ellesmere Island, and that unconfirmed. Feilden (in Nares, 1878, vol. 2, p. 213) says, "I found a pair nesting in a lofty and inaccessible cliff near Cape Hayes on August 16, 1875." However, Nares (1878, vol. 1, p. 93), who was ashore near Cape Hayes (now Point Hayes) on that date, describes the observation as follows: "Two ivory gulls were flying about the cliff, probably near their nests." The evidence of breeding near Point Hayes is therefore perhaps questionable.

The records of the Ivory Gulls from the Beaufort Sea coast were both made by Dr. Richardson. The first refers to a breeding site in a ravine near Keats Point, examined on August 16, 1848. Richardson says (1851, vol. 1, p. 281), "An isolated column . . . had been selected as a breeding-place by two ivory gulls, who were very clamorous when any one approached their nest. The young had ash-grey backs, and were nearly fledged." He found the species breeding again on the cliffs of Cape Parry in great numbers (Swainson and Richardson, 1831, p. 419). R. M. Anderson, after extensive ornithological investigation in the area expressed doubt about the validity of these records (Anderson, unpub. MS.). No Ivory Gulls have since been seen at Cape Parry, although the cliffs have been visited by Clarke (1944), Manning (oral), Macpherson (with Manning in 1951), and Höhn (1955, p. 43). The latter observer noted six to ten pairs of Glaucous Gulls nesting there. The fact that Richardson twice identified the species breeding in an area from which it is now absent might suggest either a range fluctuation over the last century or a misidentification by Richardson. It might perhaps be mentioned that the same observer also recorded the "common kittiwake" breeding at Cape Parry (Franklin, 1828, p. 237), an occurrence never since recorded.

To sum up, there appear to be fairly reliable records of the breeding of the Ivory Gull at Cape Krabbé, Prince Patrick Island, and on the Polynia Island in 1853, and near Meighen Island in 1916, and possibly on the Beaufort Sea mainland coast in 1848, but none have been confirmed in recent years (some of the places have probably not been revisited during the gull's breeding season since their discovery). It seems possible that Ivory Gulls once nested at Cape Parry, but it is very unlikely that they do so still. The existence of a colony in the interior of Brodeur Peninsula has thrice been reported to biologists by Eskimos of north Baffin Island; the statement of Ross that Ivory Gulls breed at Port Bowen (although open to question) and the fact that Ivory Gulls have been seen in the interior of Brodeur Peninsula in mid-June, tend to support the Eskimo reports.

A RECENT RECORD

Johansen's remark (1958, vol. 2, p. 40), quoting Uspenski, that Ivory Gulls perhaps breed on the large drifting ice islands of the Arctic Ocean, has led to the hope that the problem of the breeding range of the species in Arctic Canada might soon be solved. This possibility has now been confirmed by the discovery of a colony of gulls nesting on an ice island about 25 miles north of Amund Ringnes Island.

While on a traverse flight by helicopter north of Amund Ringnes Island in connection with the Polar Continental Shelf Project, Mr. L. W. Sobczak, of the Dominion Observatory, and Mr. G. Schibye, of Autair, noted a flock of white birds flying about a dark mass on the sea ice. Upon closer observation, the dark area appeared to be a small island about 500 feet square, upon which many white gulls were nesting. As this island was not shown on any map, they landed to investigate. Sobczak determined by a gravity reading that the island was floating and on June 25, 1960, established its position as 79°13.2′N., 97°29.1′W.

The surface was completely covered with rocks and coarse gravel (*see* Plates I and II). Many small white gulls (estimated to number 75 to 100 pairs) flew about screeching and swooping at the intruders.

Nests, three to five feet apart containing either two or three eggs, were located in shallow depressions among the rock debris. No nest material was used except a few feathers from the gulls themselves. Sobczak collected one egg (on June 25) which contained a very small embryo. This egg was, unfortunately, left at Isachsen Weather Station. To our knowledge, no other specimen has been taken from this colony. The birds have thus been identified solely by descriptions provided by Sobczak and photographs taken by Schibye. On comparing the bird shown in Plate IA with photographs of Ivory Gulls taken on the breeding grounds in Spitsbergen, we feel that there is no doubt that the birds nesting on this floating ice island are Ivory Gulls.

Thus we may now say that the Ivory Gull breeds in Canada on low beaches, shoals, and debris-covered ice islands fronting the polar pack, perhaps on the cliffs of the east coast of Ellesmere Island and probably also in unknown situations inland from Port Bowen on Brodeur Peninsula. Certainly the ecological and historical factors leading to such a remarkable breeding distribution merit careful study.

The reader will have noted, perhaps with surprise, how much our understanding of the distribution of the Ivory Gull depends on the accounts of the early travellers in the Canadian Arctic. In conclusion, therefore, a tribute must be paid to the energy and devotion to knowledge of the many travellers who have made their observations available to an interested public. Acknowledgment is also made to Mr. Sobczak and Mr. Schibye for recording ornithological data in addition to their regular observations; to Mr. Arthur Collin of the Department of Mines and Technical Surveys, for bringing their observations to our attention; to P.P.G. Bateson, of King's College, Cambridge, for his comments on an early draft of the literature review; and to Mrs. G. A. Langdon, Royal Geographical Society, for kindly examining for us the journals of Lt. Hooper and Midshipman Westropp.

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NOTE:

While this paper was in press, an important contribution to the breeding distribution of the Ivory Gull in North America has been published by FINN SALOMONSEN, 1961. Dansk Ornith. Foren. Tidsskr., 55: 177-180.

NOTES ON THE MAMMALS OF PELEE ISLAND, ONTARIO

By A. W. F. Banfield

Pelee Island, in the western end of Lake Erie, is of special interest because it is the most southern significant piece of the Canadian domain. Middle Island, approximately 100 acres in extent, lies about a mile farther south at lat. 41° 36′ N. Pelee Island is the most northerly of a group of islands that span the western end of Lake Erie from Sandusky Bay, Ohio, to Point Pelee, Ontario. A channel, 8¼ miles wide, separates it from Point Pelee.

These islands are composed of low Devonian limestone knolls that divide the deeper eastern section of the lake from the shallow western end. The eastern part lies in a Devonian shale basin carved by the Buffalo and Dundas rivers in the Tertiary Period. West of the island chain was a raised Silurian limestone plateau, at present drowned by Lake Erie to a depth of about 25 feet (Kindle, 1937).

Pelee Island, the largest of the group, is 7¾ miles long in its north-south axis and 3½ miles wide, with an area of about 10,140 acres. Originally, it was composed of several islands of limestone and glacial till with elevations of approximately 30 feet, separated by three large marshes, 5,000 acres in extent, lying at or slightly below lake level. Marsh reclamation, commenced in 1888, has united the present island.

Continental glaciers grinding southward during the Pleistocene Epoch overrode the detached limestone ridges, carving grooves on the north-facing cliff at Scudder and filling the leeward areas with till composed of boulders and clay. Well-drilling between the limestone hillocks has disclosed that this fill is up to 125 feet in depth. Post-glacial times have been characterized by local submergence as a series of Great Lakes were impounded at the feet of the retreating glaciers. Since these ancient lake levels generally stood higher than at present, Pelee Island must have been submerged, but there may have been a low level stage. Flint (1947, pp. 261–262) wrote "it is thought likely that there was a pronounced hiatus, involving a phase of very low lake levels in post-Algonquin, pre-Nipissing time." That opinion was based on the finding of a submerged valley through the Straits of Mackinac, and on tilted strandlines elsewhere. At that time (approximately 4,000 to 5,000 years ago) Pelee Island may have formed part of a peninsula jutting out from the southern shore. Because the deepest channel lies between it and Point Pelee, it appears likely that the north channel would have been occupied by a river at least during such a low-water stage.

At present, Lake Erie moderates the climate of Pelee Island both in summer and in winter. The Island lies in the climatic belt where winter minimum temperatures are between 0° and —10°F. Because of the shallow water, the western end of Lake Erie freezes during more severe winters. On such occasions the ice provides a broad avenue for colonization by the larger cursorial mammals.

Pelee Island lies in the heart of the Niagara Section of the Deciduous Forest Region (Rowe, 1959). The island's knolls were originally covered by a dense hardwood forest of white oak *(Quercus alba)*, red oak *(Quercus rubra)*, burr oak *(Quercus macrocarpa)*, yellow oak *(Quercus velutina)*, sugar maple *(Acer saccharum)*, basswood *(Tilia americana)*, American elm *(Ulmus americana)*, hackberry *(Celtis occidentalis)*, white ash *(Fraxinus americanus)*, blue ash *(Fraxinus quadrangulata)*, and red cedar *(Juniperus virginiana)*. Other less frequent trees of more southern distribution found on the island included—black walnut *(Juglans nigra)*, shagbark hickory *(Carya ovata)*, red mulberry *(Morus rubra)*, and the Kentucky coffee tree *(Gymnocladus dioica)* (Dodge, 1914). However, all the original forest was cut down during the early settlement period, and only about 15 per cent of the island is at present forested by second growth stands.

The settlement history of Pelee has been reported by Smith (1899). It was first leased to Thomas McKee by the Indians in 1788. The initial settlement after 1804 was not successful. Permanent settlement was established in 1834 by William McCormick, and many of his descendants still remain on the island. The reclamation of the marshes, commenced in 1888 by L. S. Brown of Cleveland and Dr. J. M. Scudder of Cincinnati, was eventually undertaken as a township responsibility. There are approximately 12 miles of canals, in which the water-level is kept at 5 feet below the lake level by two pumping stations and many miles of drainage ditches. The reclaimed bottomlands were formerly used to cultivate successive crops of grapes, peaches, and tobacco. Soya beans are now the main crop. The next most important crop is a wildlife one—ring-necked pheasants *(Phasianus colchicus)* (Stokes, 1955?). The present island population is about 500 persons.

In view of the interesting zoogeographical position of Pelee Island, two brief reconnaissances were undertaken, September 17–20, 1958, and July 17–31, 1960, to investigate the mammal and herpetological fauna. Approximately 500 trap-nights were set, and other species were collected with a .410 shotgun. An annotated list of the mammals known to have occurred on the island follows. The specimens taken are in the National Museum of Canada.

Acknowledgments

I am indebted to Mrs. K. E. (Fetherston) Ball who kindly placed at my disposal her mammal notes made on the island during 1946 and 1947 while she was studying the pheasants.

ANNOTATED LIST

Little brown bat *Myotis lucifugus lucifugus* (Le Conte)

During the summer of 1946 Mrs. Ball saw a little brown bat hanging asleep in a barn but was unable to capture it.

Red bat *Lasiurus borealis borealis* (Müller)

Bats were rarely observed. Three were shot at dusk as they flew about a school-clearing in the woods. They were all red bats.

Specimens taken: NMC 27898, July 18, 1960
27900, July 21, 1960
27899, July 27, 1960

Cottontail *Sylvilagus floridanus mearnsii* (J. A. Allen)

Cottontails are extremely abundant on the island. They constitute an important game species. Stokes (1955?) cites Hugh McCormick as his informant that cottontails were introduced to the Island about 1882 to 1884. Smith (1899) reported that the cottontails were not native to the island. Jones (1914) reported them as commonly observed.

Specimen taken: NMC 27904, July 19, 1960

Grey squirrel *Sciurus carolinensis pennsylvanicus* Ord

According to Stokes (1955?), grey squirrels which were introduced in the early days of the settlement disappeared after the introduction of fox squirrels. The last one was reported about 1913. Jones (1912) reported observing black squirrels at Fishing Point during the summer of 1910.

Fox squirrel *Sciurus niger rufiventer* G. St-Hilaire

Fox squirrels are commonly distributed in the drier wooded areas of the island. They were introduced by Charles Mills of Sandusky, about 1890, with stock from southern Ohio. Although the squirrels thrived at first, they were later reduced by excessive hunting according to Lloyd (1925). Jones (1912) reported killing one at the tip of Fishing Point in 1910.

Specimens taken: NMC 26602, Sept. 18, 1958
27901, July 27, 1960

Two others in the collection were secured by Mrs. Ball in 1948:
NMC 24129, Mar. 17, 1948
19320, Apr. 1948

White-footed mouse *Peromyscus leucopus noveboracensis* (Fischer)

The white-footed mouse is the only small terrestrial mammal native to the island. It is commonly distributed in the wooded areas as well as among the shrubs and driftwood along the beaches. The latter habitat is occupied by the deer mouse *Peromyscus maniculatus bairdii* (Hay and Kennicott) along the shores of Lake Erie. Saunders (1932) reported that *bairdii* was a recent invader of southwestern Ontario, the first specimen having been taken on Point Pelee on May 31, 1907. The subspecies later spread northeastward across the province. Its absence from Pelee Island supports the conclusion that it is a relatively recent arrival that has not yet had the opportunity to immigrate to Pelee Island. Jones (1912) reported white-footed mice on the island in 1910.

Specimens taken: a total of six adult males and two adult females were preserved (NMC 26627–8, 27904–8) during the present investigation. Mrs. Ball also preserved six taken during 1946 and 1947 (NMC 24130–24135). Average measurements (mm) of 11 adults are as follows: total length 175(160–189), tail 79(71–84), hind foot 21(19–22), ear 17(15–18); weight 26.9(23–30) gm.

Meadow Vole *Microtus pennsylvanicus pennsylvanicus* (Ord)

Mrs. Ball caught two in haycocks in 1947. They must be rare and local in distribution as none were obtained in extensive trapping in 1958 and 1960, nor was any evidence of their occurrence seen in the fields. It seems likely that meadow voles have been recently introduced to the island in shipments of hay.

Muskrat *Ondatra zibethica* (Linnaeus)

Muskrats are common residents of the canals and marshes on the island. At one time they were more important as a fur resource. Smith (1899) reported that 5,000 to 6,000 were taken annually.

House Mouse *Mus musculus domesticus* Rutty

An introduced house pest. Mrs. Ball obtained a specimen (NMC 24136) on June 19, 1947.

Norway Rat *Rattus norvegicus* (Berkenhout)

An introduced pest in barns and store houses. A flattened specimen was observed on the road near Scudder, July 17, 1960.

Raccoon *Procyon lotor* (Linnaeus)

Smith (1899) reported raccoons as residents of the island. Stokes (1955?) reported that P. McCormick informed him that raccoons had been occasionally trapped on the island until 1910. They might have reached the island as mascots on lumber scows in the early days. Two raccoons were trapped on the island during the winter of 1950–51.

Red Fox *Vulpes vulpes* Linnaeus

Smith (1899) reported that red foxes had occasionally crossed over to the island in winter on the ice. These had been usually dispatched by the residents soon after their arrival.

Wapiti *Cervus canadensis* Erxleben

Smith (1899) reported that "elk horns" had been discovered on the Island by the early settlers.

White-tailed Deer *Odocoileus virginianus* (Zimmermann)

Smith (1899) reported that "deer horns" were found on the island by the early settlers. Stokes (1955?) reported that the deer was extirpated about 1887.

CONCLUSIONS

The mammalian fauna of Pelee Island is extremely meagre. Only one small terrestrial species, *Peromyscus leucopus,* seems to have naturally colonized the island. Larger species, such as *Procyon lotor, Vulpes vulpes, Cervus canadensis,* and *Odocoileus virginianus,* probably walked over on the ice during the winter. At least one species swam to the island: *Ondatra zibethica,* and two flew: *Myotis lucifugus* and *Lasiurus borealis.*

The other species: *Sylvilagus floridanus, Sciurus carolinensis, Sciurus niger, Microtus pennsylvanicus, Mus musculus,* and *Rattus norvegicus* were introduced by man, the first three intentionally and the last three unintentionally.

It seems likely that the island has been submerged until relatively recent times. Had it been otherwise, only recently isolated from either shore, one would have expected a more varied small mammal fauna.

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